BIOMECHANICAL FACTORS AFFECTING PERFORMANCE OF THE HANDSPRING-FRONT SOMERSAULT AND THE FRONT SOMERSAULT

by

Richard R. Shore

A thesis
presented to the University of Manitoba
in partial fulfillment of the
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INTRODUCTION

Gymnastics as a sport dates back to the ancient Greeks. It was practiced only by men, and performed in the early Olympics, approximately 786 B. C. Gymnastics was considered to be a true test of a man's agility and strength. Through the centuries, the sport of gymnastics became more complex, involving more apparatus, and thus demanding a greater range of skills. By the nineteenth century, when women became involved in gymnastics, their participation was restricted to the more aesthetic spectrum of human motion, using only the hand apparatus of modern rhythmic gymnastics. In the twentieth century, women joined the men in the practice of artistic gymnastics, with their own variations of the men's apparatus.

There remains however, one event that is shared by both sexes, the floor exercises. Although the tumbling skills in the floor routines have become more complex, modern day gymnasts are still following the same principles of human kinetics as the first tumblers of ancient Greece. Each skill that the tumbler performs consists of a myriad of components. As the demand for a higher performance level grew, it became increasingly more important for gymnasts and their coaches to break down a movement and study each of its components in order to improve the performance of the whole.

The speed which a gymnast had to maintain in order to successfully complete the movements, made analysis of each segment very difficult. However, the current use of computer-assisted analyses, utilizing high speed cinematography has made it possible to analyze each skill in minute detail. Thus a gymnast can be given more specific information on each phase of a movement, thereby increasing the potential for a greater level of proficiency in the performance of a skill.

The Skills Analyzed

The skills analyzed were the front somersault and the handspring-front somersault. They are two movements which are executed on the floor by advanced gymnasts of both sexes. The front somersault, as shown in Figure 1, is an aerial rotation about the transverse axis, which is an axis passing through the body from left to right. It is initiated by a rapid horizontal approach run into a hurdle. The hurdle is a brief flight phase wherein the body is positioned such that the athlete lands on two feet, and then proceeds into the take-off.

Although there are three different arm positions which can be used in the take-off for a running front somersault, this study focussed on only one. The overhead and forward arm throw which can be used for the handspring-front somer-

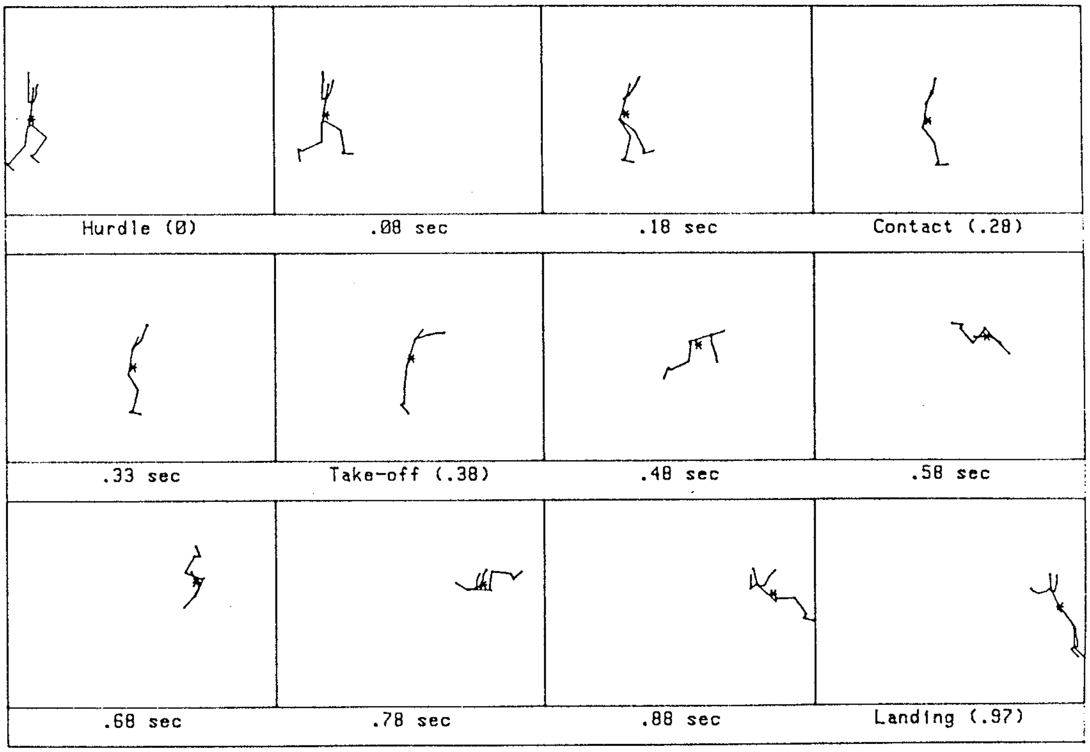

Figure 1: General motion for a front somersault

sault as well as the running somersault was the arm position utilized by all subjects. During the running approach the arms are raised above the head, so that on contact for take-off the motion of the arms was upwards and forwards. With the arms in this overhead position during take-off, the center of gravity is at a higher level than with the other arm positions.

Besides the advantagous effect of raising the C of G at take-off, the use of the arms will also increase the angular velocity of the body during rotation while in the air. In order for the arms to assist in increasing the angular velocity of the body it was necessary for them to change position relative to the rest of the body and reduce the moment of inertia of the body.

The initial rotation is produced by planting the feet firmly on the ground, as the upper body continues to move forward, due to the horizontal velocity. Another force, the extension of the legs in a sequential manner, adds to both the angular momentum and the vertical lift. This reaction force created by the legs pushing down is reported by George (1980) to be the largest contributor to both angular momentum, and vertical force.

Due to the reaction of landing from the hurdle, the hips, knees, and ankles will be flexed to cushion the impact. It is possible that this prior stretching of the gluteals, quadriceps, and gastrocnemius initiates a stretch reflex in those muscles to allow them to contract more forcefully. These joints will immediately begin to extend forcefully in an explosive manner. In any event, the extension of the hip, knee, and ankle joints occurs just before the body is past vertical. This vertical force imparted to the body by the reaction force from the ground causes an upward acceleration of the entire body. Also, since this force is applied behind the C of G it is an eccentric force, which produces the angular momentum of the whole body.

The handspring-front somersault is actually a combination of two movements. The front somersault, which has just been described, is executed after a front handspring, which is illustrated in Figure 2 . The front handspring has a horizontal approach with a hurdle onto one foot, then a step forward. The hands are moved downward to be placed on the mat at such a position that the shoulders are behind a vertical line upwards from the hands. This angled position of the arms and trunk provides a braking mechanism to achieve the correct timing so that the body can be directed upwards

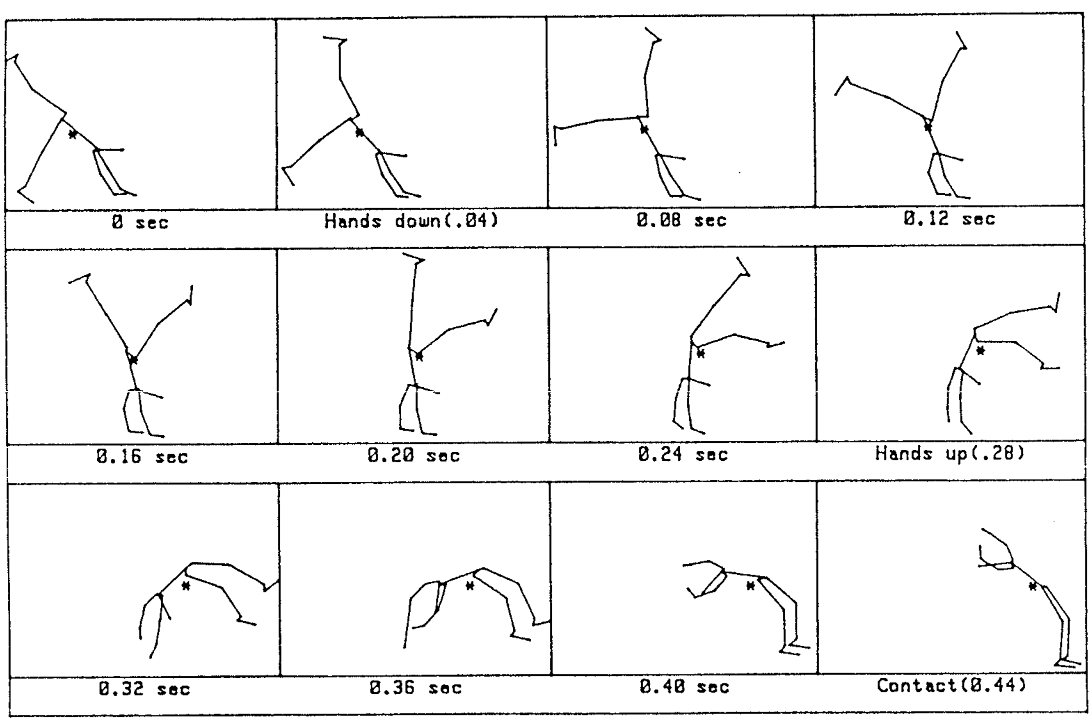

Figure 2: General motion for a handspring

and rotated around the hands.

This study addressed some of the problems created by the differences of opinion among the various studies previously completed on these gymnastic movements. Through the present author's analysis of the factors involved it is hoped that athletes, coaches, and teachers will be better equipped to perform and teach these movements to a greater degree of excellence.

Statement of the Problem

The purpose of the present study was to examine the following mechanical factors and compare them between the front somersault and the handspring front somersault:

1. The differences in ground reaction forces at take-off
2. The differences in the angular velocities of the body segments
3. The differences in the angular momentum of the airborne phase of the skill
4. The differences in the angle of contact between the toes and the C fo G
5. The differences in the angle of take-off between the toes and the C of G
6. The time taken for the execution of each of the somersaults
7. The differences between the height and horizontal distance travelled by each of the somersaults.

Hypotheses

The following hypotheses are suggested for the proposed analysis of the somersaults:

1. The angle of the legs on contact will be closer to the vertical for the running front somersault
2. The angle of the legs on take-off will be further from the vertical for the running front somersault
3. The times for take-off will be similar for both types of somersaults as the skill of the performer improves
4. The height attained in the running front somersault will be greater than that attained from the front handspring
5. The distance travelled by the running front somersault will be greater than that from the handspring
6. The angular momentum in the running front somersault will be larger than that of the somersault from the front handspring.

Delimitations

In this study there were only thirteen subjects. The two groups will consist of seven males and six females. Only those subjects who could already perform these two moves were considered for the population. The subjects were all chosen from the location in or around Winnipeg.

Limitations

The study focussed on the front somersault on the floor when performed with an overhead arm lift. The two approaches were from a run or from a front handspring. Other techniques were not analyzed. The subjects performed the movements on a double layer of floor exercise mat. This was different from their normal surfaces for tumbling maneuvers since all subjects train on spring floors in their respective clubs. The double layer provided a sufficient landing surface and did not impede the forces exerted on take-off by any of the gymnasts.

REVIEW OF RELATED LITERATURE

Introduction

Studies leading to the documentation of information on the mechanics of specific gymnastic skills have been carried out basically by two segments of the population. There are the biomechanists, who are interested in the skills purely from a research point of view, (Hay (1975), and Hebbelinck & Borms (1968)). Information is also forthcoming from coaches and the gymnasts themselves, who benefit from the practical application of the knowledge, (George (1980) and Gluck (1982)). It is the union of these two groups which fosters the greatest potential for gain in knowledge to improve the performance of the skills. When the gymnasts use the information to advance or change their technique in a skill, progress can be made.

Journals and periodical articles which contain information on the method of analysis, or the movements being performed, also are useful (Ellard & Kerr (1979); Knight, Wilson & Hay (1978); Brown (1974); Kinolik, Garhammer & Gregor (1980); Lamb & Stothart (1978)).

In the subsections which follow, the review of related literature will be classified under these subheadings: 1) mechanics of the handspring, 2) mechanics of the somersault, 3) biomechanical methods.

Mechanics of the Handspring

General Description

The handspring is a rotation of the body around a transverse axis. The hands are the first axis about which the body rotates, while the hands are in contact with the ground. Then a flight phase occurs wherein the body rotates around an axis passing through the center of gravity to land on the feet. Figure 2 identified the motion of the handspring performance.

Leg Action

Some gymnastics coaches, (Taylor, Bajin, & Zivic (1972); and Hughes (1966)), agreed that in the front handspring, the rear leg must be forcefully thrust up and backwards in a straight position. There was an additional force provided by the rear leg as suggested by Kinolik, Garhammer & Gregor (1980). In their study of an aerial walkover it was noted that 40% of the value of the front leg force could be generated by the downward thrust of the rear leg. The same principle would hold for a handspring, in that both legs should be flexed on the floor followed by a downward push. Then the rear leg would be swung upwards and backwards. Baley (1968) and Edwards (1969) indicated that the front leg is planted in a flexed position, then extended to provide force to raise the center of gravity. Discrepancy arises, however, as to the use and timing of the arms.

Arm Action

Kalakian & Holmes (1973) stated that extending the reach of the arms created a "blocking action" which facilitated the change in direction that the body would achieve. The blocking action was such that the shoulder girdle muscles contracted to arrest the forward motion of the shoulders when the hands were placed on the ground. This movement forced the body to use the hands as a pivotal point and created an upward motion of the entire body. Bowers, Fie & Kjeldsen (1972) also noted a blocking action of the arms and shoulders.

Hebbelinck & Borms (1968), by means of an electromyographic, and cinematographic study, showed that the muscles in the arms and shoulders contract forcefully and provide lift and some angular rotation in the front handspring. The shoulder and arm muscles involved were the trapezius, rhomboids, deltoids, latissimus dorsi, triceps, and pectorals. The actual push from the arms was described by most authors to be with straight elbows, utilizing shoulders and wrists. Loken & Willoughby (1977) emphasized pushing off the floor from the shoulders and wrists, without bending the arms. This type of push would then require that the shoulders be depressed and then elevated to allow the arms to remain straight, as well as utilizing an extension action of the wrists.

The description of the push off from the hands varies widely. Kunzle & Thomas (1956) noted that the maximum thrust from the floor would occur if the shoulders were elevated at the instant that the hands touched the ground. Weiler (1970) advised that the fingers should be utilized for pushing from the floor just prior to the body reaching a handstand position. This push off must occur early in order for the body to be projected upwards. Momentum from the approach run would provide the necessary rotation. Hughes (1966) suggested that the hands would be leaving the mat at the moment that the legs passed through the handstand position.

Trunk Angle

Edwards (1969) was in agreement with a push off with the trunk in a vertical position, while Kinsmen (1978) in the Level II Canadian Coaching Manual described the push off as occurring before the body is vertical.

The author agreed with the views of those who promoted a push off with the body at an incline, or before vertical. However, there may be differences which occurred due to the movement performed after the front handspring. A push off which is more directly in line with the vertical may allow for a lower handspring, since it does not provide any retarding of the forward momentum. This may be of some benefit for a technique in which the center of gravity is rising throughout the move, instead of one in which the C of G drops down from the high handspring, and then rises again in the somersault.

Transfer of Momentum

In their articles on the front handspring, Warren (1967), Tucci (1977), and Kralik (1979) all advocated a blocking action of the arms, and suggested that the momentum produced by the swinging leg can be transferred to the body provided that the gymnast remains taut, and the leg is decelerated while on the up swing.

While the hands are being planted, the rear leg is rotated upward and backwards rapidly. This swinging leg provides angular momentum to the body system. With the support leg in a flexed position, the weight of the body itself will add some angular momentum, and the extending of the support leg may add to both the angular momentum and vertical height.

Mechanics of the Somersault

Hurdle and Take-off

The purpose of the hurdle is to alter the body from a running motion to a position whereby both feet are in contact with the floor to prepare for an impact jump. There is a difference of opinion on the method of execution of the hurdle. A low, short hurdle is suggested by George (1980), while Ellard et al. (1979) indicated that it should be low and long. Jensen & Schultz (1970) suggested that there was a short and rather high hurdle. The purpose of this hurdle is to check forward speed and convert some of it to vertical momentum. This is in opposition to other statements concerning the benefits of a low and quick hurdle movement. In any event, all authors agreed that the legs should be angled backwards on contact, so that the feet are in front of the center of gravity (C of G). This blocking, or retarding effect will tend to slow down the horizontal velocity, as well as tending to assist in a proper position to apply vertical forces to increase the vertical velocity. Angular rotation about an axis passing through the feet was also present at take-off.

Kreighbaum & Barthels (1981) summed up the effects of take-off with the following points. They stated that when a body was projected into the air by a force, which occurred for a set time interval before take-off and acted eccentrically to the center of gravity of the body, there would be two motions. One would be a linear motion of the C of G, and the other would be a rotation about the C of G once the body was airborne. The velocity would be proportional to the magnitude of the force applied, the perpendicular distance of the line of force from the axis, and the length of time that the force is applied. It was also noted that rotation may be occurring while the body is still in contact with the ground. In this case, the force of the person's weight becomes a torque producing force. Hay (1978) indicated that it is the reaction to the legs driving forcefully into extension on take-off that is the main cause of lift and angular rotation.

Fukushima & Russell (1980) also showed a low, quick jump; and proposed a take-off with no forward lean. Schmid & Drury (1977) stated that take-off should be vertical, Garstang (1964) suggested that take-off is upwards and slightly forwards, and Kinsmen (1978) in the Level II manual also recommended a forward body lean at take-off. Puckett & Bengtson (1979) commented that the hurdle should be low while elevating the arms, then "blocking" straight up out of the ankles.

For the combination of the two movements of handspring and front somersault, differences are again evident in the studies of various authors. Angles of landing to take-off are stated as ranging from backwards lean, to vertical, to forwards lean. Fukushima et al. (1980) stated that the body should have the hips and chest hyperextended, with the arms behind the head, to lift into a high front somersault. Cooper (1973) suggested that the landing is in a vertical position with the arms extended overhead. Edwards (1969) described the landing as a position in which the body weight moves beyond the base of support. A different approach to the front somersault is presented by these positions.

George (1976) discussed the movement preceding an aerial skill and stated that the degree of blocking or angulation of the body should be commensurate with the speed and direction of the body's mass center just prior to being airborne. This indicated that there would be a larger blocking effect in a front somersault than in a handspring-front somersault. George (1980) added that the handspring which is followed by another movement will require a more vertical position on the completion of the handspring.

Cochrane (1969) described the combination of movements by implying that the handspring should be light and high, with a vertical landing position for the body and the hands overhead. As the feet contacted the mat from the handspring, he stated that the gymnast would rebound upwards from the feet, while reaching upwards and forwards into the front somersault. Baley (1965) had a similar view of the high handspring before the somersault.

Hay (1975) discussed jumping techniques, and noted that for the long jumpers, a higher velocity resulted in less contact time with the ground on take-off, and in general a longer distance jumped. He also stated that in a high jump, the length of time in contact with the ground was about 0.12 seconds for the flop, to 0.18 seconds for the straddle. The long jump times of between 0.08 and 0.13 seconds were recorded. This is also the range of contact times that should be produced by the somersault.

The recording of contact time with the ground differed in two different studies conducted on the front somersault. Brown (1974) found that contact time was 0.23 seconds for both an overhead lift, and a Russian lift front somersault. Knight & Wilson (1978) indicated that the take-off time lasted only 0.13 seconds. In vaulting it was found by Penney (1977) that the take-off time was approximately 0.1 seconds. One half of this time was used in moving the body forward to attain proper take-off angle, and the remainder was used in extending the legs. Penney (1977) undertook an experiment on different types of coverings for vaulting boards. The times and angles showed no particular change for any of the types of pads used.

Creation of Rotation and Angular Momentum

The rotational momentum for the front somersault has been described as the result of several different body motions. Munrow (1963) related two ideas: one was the acquisition of momentum from friction between the foot and the floor, and the other was the position of the feet so that they pushed eccentrically to the line through the center of gravity. Baley (1965), Taylor et al. (1972), Loken et al. (1977), and Hughes (1966) all indicated that the angular momentum is established by a blocking action of the legs to transfer horizontal momentum into vertical momentum and rotation. The other component of angular momentum that can be established from the ground is the eccentric thrust produced by the legs pushing up, with the C of G in front of the feet. Some transfer has been related by the overhead arm position, with the movement forwards and upwards.

Gluck (1982) indicated that by fully extending the leg joints, the time that the force could be applied to the ground and the direction of force application are enhanced. The result would be the occurrence of a greater vertical and angular impulse. Also, the ability to fully extend the legs on take-off allowed a larger reduction in rotational inertia to occur while in the air, so that a higher angular velocity could be achieved, with any given angular momentum at take-off.

Hay (1978) reported moments of inertia for the extended body position with hands over the head to be 15.12 kg-m^2, and for a body in tuck position to be only 3.50 kg-m^2. Therefore, if the body leaves the ground in an extended position, and then the body is tucked, the angular momentum will stay the same as take-off, but the angular velocity can be increased by a factor of 4.3.

Broer (1967) used the concept of torque to imply that a gymnast who performs a front somersault must take-off at an angle of less than 90 degrees to allow gravity to aid in the production of rotation. Hopper (1973) suggested that the torque due to the body weight rotating about the feet on take-off maneuvers will be non-effective, since it is a relatively small force, which acts on both sides of the contact point at different times during the move. This author also feels that the torque which occurs due to gravity acting on the body at take-off will have a negligible effect on the production of rotation. It will be overshadowed by the major sources of angular rotation which are the forward velocity of the body over the feet when the feet are fixed on the floor for take-off, as well as the extension of the legs from an eccentric thrust.

O'Connell & Gardner (1972) illustrated a front somersault with the angular velocities for the trunk and lower body occurring at different times. The trunk appears to rotate through a greater angle in the initial time frame, while the lower extremities swing through a greater angle at a slightly later time. Barham (1978) stated that the momentum which is fixed at take-off can be altered only while in contact with the floor. Once airborne, the rotational momentum is fixed, however the inertia and velocity can be altered.

Angular momentum of the front somersault in flight varied according to the authors read. Hay, Wilson, Dapena & Woodworth (1977) showed a value of 65.39 kg-m^2/sec, Knight et al. (1978) found 53.56 kg-m^2/sec., and Kinolik et al. (1980) found an impulse of 61.7 Nms in an aerial walkover. Ellard et al. (1979) indicated that the angular momentum is directly related to the angle of the trunk during take-off.

Margaria (1976) related the power and efficiency of jumping to a stretch prior to the jump. The study indicated that when a vertical jump is performed from the upright position the initial motion is a flexion of the knees, which causes the extensor muscles of the legs to become stretched. This stretching was claimed to load the muscles with an elastic energy. Later it was noted that chemical energy is conserved by this initial stretch in the negative phase of work, which would enable the release of greater power and efficiency in the positive phase of work performance. Presented here are two quite different components which will each have an effect on the outcome of the somersault. The impulse jump will stretch the extensor muscles of the legs, and the take-off angle will have a direct relationship to the amount of effective torque generated.

Path of the Body

Several authors, including Kreighbaum & Barthels (1981); and Miller & Nelson (1973), have noted that the C of G in aerial moves follow a parabolic trajectory, since the only external force acting on the body while it is in the air is gravity. Northrip, Logan, & McKinney (1979) stated that the actual path of the center of gravity is often masked by motions of other body segments as they move, or rotate about the mass center.

The flight of the center of mass in the front handspring can be low or high. Biesterfeldt (1975) showed a model of a back handspring which maintained a low flight with the C of G rising throughout, so that the final direction of the C of G was upwards, rather than downwards as would be the case in a high back handspring. The same principle should apply to a front handspring, so a performer who wished to spring out of a front handspring into a somersault, should maintain a low flight in the front handspring in order to achieve this flight up and into the somersault.

Biomechanical Methods

Cinematographic Techniques

High speed cinematography has become a useful tool in biomechanical analyses. Many authors have used high speed film to record various motions and then determine their results by studying the films, (Brown (1974); Hay (1975); Hebbelinck et al. (1968); Knight et al. (1978); Smith (1983)).

Engin (1977) related a number of assumptions used in cinematography. Since the photograph is planar it was assumed that this plane can approximate the movement model. It is also assumed that the spatial orientation of the plane of the photo is known at all times. The movements being analyzed both represent fairly two dimensional motion, therefore the plane should be quite accurate. Also, since both limbs should undergo the same motion during the time when the body landmarks are hidden, they were able to be approximated by the visible limb.

Force Determination From Film

Miller & Nelson (1973) indicated that the ground reaction forces can be calculated using the knowledge of the velocities of the center of gravity, and working backwards through the equation of force equals mass times acceleration.

Another method of calculating velocities, accelerations and forces was also employed, based on a study made by Smith (1983). He based his model on an average force applied throughout. The assumption this author made is that this force will be about one half of the peak forces calculated by the smoothed data. This assumption is based on the idea that the force during the time of contact will not be a constant. Since Smith (1983) showed his force calculations were based on finding the force required to change the velocity from zero to take-off velocity over the time period where the body moved from its lowest point to take-off. This would utilize the impulse-momentum relationship whereby the force required to change the velocity of the mass of the body is exerted over a specific time period. This would appear to imply that the force was a constant over the entire time of extension.

Force Plate Studies

The take-off appears to be the critical movement of the front somersault and the handspring-front somersault. Knowing this, it is necessary to measure the ground reaction forces accurately. The most accurate device to indicate the magnitude of vertical and horizontal forces imparted to the ground by the athlete is a force plate. Bedi & Cooper (1977) related the angular momentum and braking force in the long jump to the data derived from force plate analysis. Cavanagh (1978), and Cavanagh & Lafortune (1980) showed ground reaction forces in runnning and indicated that peak forces of approximately three times body weight occurred in the vertical direction, and of one body weight in the horizontal direction. They also discussed the change of point of pressure on the sole of the foot throughout the foot plant. Duck (1980) noted the difference in ground reaction forces from a stand as compared to that of an impulse jump. An impulse jump is one in which the body is jumping off the ground from an initial landing. This initial landing is of short duration and can load the muscles with an elastic energy. The muscles are placed into a stretched position, which is an eccentric contraction, whereupon they begin to contract concentrically. The readings indicated that the increase shown was approximately twofold for an impulse jump. He also discussed the contribution made by the arms in isolation. With the use of a force plate, the overhead throw whereby the arms were moved forwards and upwards from an overhead position, showed a small increase in both vertical and horizontal force.

Actual measures for impact forces seem to vary greatly in various studies. As already mentioned from Cavanagh et al. (1980) peak running forces were measured at three times body weight vertical and one body weight horizontal. Kinolik et al. (1980) while using a Kistler force plate found forces of 3.3 times body weight on the take-off leg for an aerial walkover. Another study utilizing a Kistler force plate was carried out by Coutts (1982), where he compared the hop style to the step-close technique in volleyball jumping. He found forces averaging 1732 Newtons for the hop style or about 2.8 times body weight. Biesterfeldt (1975) discussed forces from a back handspring as being five to nine times body weight. Smith (1983) used a dynamometer consisting of two surfaces with helical springs between and fitted to measure the forces generated. In his study of the take-off into a back somersault, he recorded forces of 2715 Newtons, or about five times body weight vertically, and 1160 Newtons or just over two times body weight horizontally. He also presented a method of calculating these forces, which is shown in Appendix A. It is notable that he is reporting an averaged force for vertical calculations, and that his recorded forces must have been damped too much.

Payne & Barker (1975) compared the forces in a back handspring when leading into another back handspring or into a back somersault. They utilized a force platform and cinematography for their analysis. Their results showed forces measured in the range of 200 kilograms for the Y-force over a time interval of 0.7 seconds. This seems to be a very long ground time and quite low forces when other authors such as Bruggemann (1983) and Nissinen (1978) are compared.

Bruggemann (1983) studied the take-offs for a back somersault and a double back somersault. With his analysis, a Kistler force plate was also employed. His maximum vertical ground readings averaged 6069 Newtons for a single somersault, and 6846 Newtons for a double somersault. Horizontal forces were recorded at -1900 Newtons and -2100 Newtons respectively. These figures are much higher than any other registered by the other authors. Although he does not give the mass of any of the subjects, if an assumed mean of 70 kg is used, this would produce vertical forces ranging from 8.8 to 10 times body weight, and horizontal forces from between 2.7 and 3 times body weight. As well the suggestion was made that the impact forces were reduced due to the mats placed over the force plate. Thus, even with force plate studies a discrepancy seems to arise as to what values could be expected for vertical and horizontal forces.

Another study which indicated much larger forces was performed by Nissinen (1978). In his study of the running and support phases of a front somersault, he recorded values from a Kristal Type 9261A force platform. He indicated that vertical forces of up to 15 times body weight during impact, in the first 20 milliseconds of contact, were found, and that during the thrust period forces of 5 to 6 times body weight occurred.

Ramey (1975) discussed some of the types of force plates and indicated the problems associated with their operation. Proper calibration, cross-talk between axes, dampers to eliminate vibration, and sensitivity are some of the variables mentioned that must be dealt with in installing and operating a force plate.

The use of a force plate and cinematography have been compared to identify the validity of using the force plate data to derive velocity curves. Lamb & Stothart (1978) tested the two methods on a group of male college students performing the vertical jump. Their findings indicated that the forces on the plate measured the forces directed through the center of gravity. There was a high correlation of data for both film and force plate velocities.

Body Segment Parameters

Two problems which have been shown to cause difficulties in other studies are the accurate determination of body density, and segmental weights used in calculations. Sinning (1978) studied the anthropometric composition of women gymnasts and found that there was a constant error in equations, due to the tendency of women gymnasts to be small and lean. Hay et al. (1977), in their study of angular momentum, found that the clarity of filming and collection of data for the front somersault was excellent. However, the results obtained were worse than that of other studies of different moves. They determined that the results were improved by reducing the mass of the upper limbs of the subjects, and moving the center of gravity lower in the body.

Ramey & Yang (1981) indicated that simulations of moves may be made with the proper equations and an a priori knowledge of the desired changes. This is difficult at present since accurate measurements of subjects segment inertia is not possible.

There have been a number of studies Diffrient et al. (1974); Plagenhoef et al. (1983) which have dealt with the analysis of human segment parameters. The main items which are needed for analysis in a biomechanical study are:

1. the center of gravity of each segment

2. the mass of each segment
3. the moment of inertia about the transverse axis of each segment.

METHODS AND PROCEDURES

Introduction

The technical difficulty involved in the performance of the front somersault and the handspring-front somersault limited the sample to a relatively advanced calibre of gymnast. Since the surface of the take-off could have caused a difference in performance, a common surface for all subjects was chosen. This choice was a double layer of floor exercise mat. The two layers were placed on a hard surfaced floor in the Brown Gymnasium at the University of Manitoba.

Subjects

The subjects were local gymnasts from the Winnipeg area. Seven male subjects were chosen, with three from the University of Manitoba gymnastics team, and the others from a younger age level. Six female subjects were chosen, with three from the provincial elite team or higher, and three representing lower level gymnasts. All subjects were required to perform both the skills, so that selection of the subjects was restricted to those capable of the performance of the skills. Each subject was allowed one trial of each movement after sufficient practice on the apparatus, to acquaint them with its characteristics.

Data Collection

Filming Techniques

The cinematographical data were gathered by means of a Photosonics Action Master 7250, 16 mm camera placed approximately 10 metres from the subjects. The plane of motion was perpendicular to the line of the camera. A film speed of 100 frames per second was used with Ektachrome 16 mm color movie film. The actual filming was done by an experienced cinematographer.

Each subject was given ample time to warm up and become accustomed to the take-off area. They were prepared with joint markers on the right side of the body at the following locations: wrist, elbow, shoulder, hip, knee, and ankle. The other points to be used for analysis were the right and left fingers, top of the head, right and left heel, and right and left toes. The left shoulder and hip were estimated from viewing the right side. Subjects were asked to wear white socks to enhance the photographic analysis and shorts only for the boys, and sleeveless leotards for the girls. The markers consisted of white tape with a black center, and these were placed on the bony landmarks of the body.

Performance Rating

In order to rate the performance of these somersaults, a panel of judges was selected. Three judges, nationally certified by the Canadian Gymnastic Federation, observed the film of the performers. Each somersault was judged out of ten points. All of the judges had previous experience at judging both live and from video tape, so they were well acquainted with the procedures. The three scores were then averaged and used for rating the performances, to enable comparisons between skilled and unskilled. The raw data for the subjects is reported in Appendix C and this includes the averaged judges scores.

Film Analysis Procedures

The film was projected onto the Hewlett Packard 9874A digitizer, which was interfaced with the Hewlett Packard 9835A microcomputer. The Cartesian coordinates of the joint centers of the athletes in every frame were digitized and stored on data cartridges to be analyzed.

The digitizing screen that was employed in the analysis had a resolution of one digitizer unit equivalent to 25 micrometers. There were 17,400 digitzer units in the horizontal axis of 0.435 meters and 13,500 digitizer units in the vertical axis of 0.3375 meters. Based on a previous effort to test the reliability of the digitized position with the actual position in space, the accuracy of the digitizing showed a correlation in excess of 0.99 based on a Pearson r correlation. In a paper which attempted to analyze three dimensional coordinates from two cameras in (Shore,1983), the results showed that the mean difference for measured values and digitized values was 0.004 meters. This would appear to indicate that the degree of accuracy was reasonably high.

The Hewlett Packard 9835A microcomputer was utilized to analyze the data collected. The data was analyzed to determine temporal and positional factors. Positions such as contact and take-off were isolated and noted for body angles, and time between events. The velocities and accelerations were then derived from the positional and temporal data.

The ground reaction forces, angular inclinations, and linear and angular velocities of various segments were determined. Tracings of the movement and graphs of various aspects of the skills were produced by using the Hewlett Packard 9872A graphics plotter.

Body Segment Parameters

The determination of the center of gravity of each segment was based on information from Diffrient, Tilley, & Bardagjy (1974). Their data was derived from live subjects not cadavers as is the case for most studies. Table 1 shows the center of gravity locations from Diffrient et al. (1974) which were utilized in the digitizing program to locate the body's C of G. The mass of each segment was derived from formulae in Plagenhoef, Evans, & Abdelnour (1983). Table 2 indicates the segmental masses of the body which were used in this study. The radii of gyration for the transverse axis were estimated Plagenhoef et al. (1983), who used live subjects to determine the centre of gravity, then corrected cadaver data to determine the radii of gyration for the extremities. They utilized lead models to determine trunk and head radii. These radii for the body segments are given in Table 3.

TABLE 1

Body Segment Centers of Gravity from Humanscale

Segments	Distance from proximal joint
Head	50.0%
Trunk	50.0%
Upper Arm	43.6%
Forearm	43.0%
Hand	28.0%
Thigh	43.3%
Shank	43.3%
Foot (from heel)	45.0%

* from Diffrient (1974)

TABLE 2

Body Segment Mass as a Percent of Total Body Mass

Segments		Percent of Entire Body Mass
Head	m	8.3%
	f	8.2%
Trunk	m	46.9%
	f	45.0%
Upper Arm	m	3.3%
	f	2.9%
Forearm	m	1.9%
	f	1.6%
Hand	m	0.7%
	f	0.5%
Thigh	m	10.5%
	f	11.7%
Shank	m	4.7%
	f	5.3%
Foot	m	1.5%
	f	1.3%

* from Plagenhoef (1983)

TABLE 3

Radius of Gyration of Body Segments about the Transverse Axis

Segments	Per Cent of Segment Length from Proximal Joint	
	Male	Female
Head & Neck	61.0	61.0
Trunk	81.0	75.0
Upper Arm	54.2	56.4
Forearm	52.6	53.0
Hand	54.9	54.9
Thigh	54.0	53.5
Shank	52.9	51.4
Foot	69.0	69.0

* from Plagenhoef (1983)

Kinematic Analysis

Positional and Temporal Analysis.

The speed of the film was checked by using a clock which was visible from the view of the camera. The clock, which rotated at one revolution per two seconds, was scaled so that the frames could be counted during the digitizing process and compared to this revolution time.

One item of interest was the time between contact and take-off. This was noted by analyzing the number of frames between these two events. Height and distance travelled by each of the somersaults was also compared relative to the subject's height.

The height of the C of G or other body part at various times throughout the movements was analyzed by comparing the digitized points for the toes at the take-off frame, which was ground level, and a specific point on the body such as the hip or C of G. The difference between the Y-coordinates indicated the difference between the floor and that body joint or the C of G, at that particular moment. The formula to be used was:

$$H = (YCofG - YRToe) * Cfact \quad (1)$$

where H = the difference in height; YCofG = the calculated Y-coordinate in digitizer units for the C of G; YRToe = the digitized Y-coordinate of the right toe, on take-off; and Cfact = the conversion factor from scaling the film.

The distance travelled in flight was derived using two different body parts. It was done by finding the difference between the X-coordinates of the right toe from take-off to landing, as well as the X-coordinates of the C of G from take-off to landing. The formula to used was:

$$D = (XRToeLand - XRToeTakeoff) * Cfact \quad (2)$$

where D = distance travelled horizontally; XRToeLand = the digitized X-coordinate of the right toe at landing;

XRToeTakeoff = the digitized X-coordinate of the right toe on take-off; and Cfact = the conversion factor. Note that this formula could be modified to return the horizontal distance of any required body part or the C of G.

The time intervals for various parts of the movements were analyzed by noting the difference in number of frames between the start and finish of that part of interest. The formula used was:

$$T = (F(\#)end - F(\#)begin) * Time \qquad (3)$$

where T = the time of execution; F(#)end = the number of the frame at the end of the portion being analyzed; F(#)begin = the number of the frame at the beginning of the motion being analyzed; and Time = the frame speed in seconds per frame.

The angles of contact and take-off were found by measuring the angle between the toes and the C of G from the horizontal plane of the toes. The formula for this was:

$$\theta = ATN(XCG - XRT)/(YCG - YRT) \qquad (4)$$

where θ = the angle of the C of G measured from positive Y vertical; ATN = the arctan function; (XCG - XRT) = the difference in X-coordinates of the C of G and the right toes in digitizer units; and (YCG - YRT) = the difference in Y-coordinates of the C of G and the right toes.

Velocities and Accelerations.

Once the positional data had been found from the film analysis, more information was desirable. By differentiating the positional data, the linear velocity of various body parts and the C of G could be derived. The basic formula for finding the horizontal velocity was:

$$V_1 = (X_2 - X_1)/Time \qquad (5)$$

where V_1 = the average horizontal velocity between the frames indicated,

X_2 = the X-positional value of the final point,

X_1 = the X-positional value of the initial point, and

Time = the interval between the frames.

The actual computer formulae are found in Appendix B, and these enabled the instantaneous velocities to be calculated throughout the movement.

A similar differentiation was performed once more on the velocity data so that the acceleration could be found. The basic formula for finding horizontal acceleration was:

$$a_1 = (V_2 - V_1)/Time \qquad (6)$$

where a_1 = the average horizontal acceleration between the frames indicated,

V_2 = the X-velocity value of the final point

V_1 = the X-velocity value of the initial point

Time = the interval between frames.

Note that the computer programs are designed to calculate instantaneous velocities and accelerations throughout the skills. Another method used to find the velocities and accelerations was shown by Smith (1983). In his method, the velocities and accelerations were averaged over the entire ground time or air time. The equations were similar to those shown, the only difference was that they are averaged over a longer time period.

Kinetic Analysis

The kinetic analysis examined the forces that caused the motions which were analyzed in the previous sections. The forces were analyzed by two different methods. Both results will be shown, compared and discussed. Also a comment on the trials involving the force plate, located at the Engineering department on the University of Manitoba campus, will be made.

The Engineering department at the University of Manitoba had an outdoor force plate which was connected on line to an IBM computer for recording vertical, horizontal and lateral forces. Three gymnasts were chosen to perform the front somersault from the force plate. The lighter gymnasts from the cinematographic study were used since the force plate was not built to withstand high forces. The force plate was suspended by three wires, each capable of withstanding approximately 1100 Newtons force. The trials were conducted to attempt a validation of the filmed data in its use for calculating the ground reaction forces.

Once the filmed data was analyzed for positional, velocity and acceleration information, the forces could then be calculated. The ground reaction forces were calculated in both the horizontal and vertical directions. The C of G positions were determined by a summation of the body segment masses using Diffrient et al. (1974) as the means for determination of individual segment masses. The mass of the entire body was taken from a balance scale. The assumption was made that the forces are transmitted through the C of G so the acceleration was calculated for this point. The fast Fourier transform of the positional data was taken. Some of these frequency components were eliminated, thereby smoothing the data. If this frequency information was then transformed back to the time domain, smoothed positional curves resulted. If the components were scaled by their respective frequencies and then converted to the time domain, smoothed velocity curves resulted. Finally, if the frequency components were scaled by the squares of their respective frequencies, then smoothed acceleration curves resulted. Referencing for the fast Fourier transform was from Brodland (1982).

Since the Fourier transform was performed by the radix 2 fast Fourier transform, it was necessary to provide 2^n points. If for example 11 points at time intervals of 0.01 seconds had been measured, the working N would be 2^4 or 16. Noise reduction and smoothing were accomplished by eliminating the upper harmonic components. Experience had shown that adequate smoothing was accomplished by elimination of all frequency components higher than one-eighth the sampling frequency. In this example then only one-eighth of 16 or two harmonics plus the fundamental are retained. The resulting cutoff frequency would then be:

$$(2 + 1)/(.01 * 16) = 18.75 \text{ Hz}$$

This relationship can be expressed by the fomula: cutoff frequency(Hz) = (# of harmonics retained + 1)/(time * working N). This remains within the generally accepted range of 20 Hz which encompasses frequencies found in motion of the human body.

The following formulae were used in the calculations of ground reaction forces:

$$Fx = m * ax \qquad (7)$$

$$Fy = (m * ay) + (m * 9.81) \qquad (8)$$

where Fx and Fy are the horizontal and vertical forces acting through the C of G; m = the mass of the subject; ax and ay are the accelerations of the C of G in the horizontal and vertical directions; and (m * 9.81) accounts for the force due to gravity.

The set of equations used to calculate the horizontal force from the model proposed by Smith (1983) are:

V_1 = average velocity of C of G in X-direction before contact (from film data)

V_2 = distance C of G in somersault/airtime (velocity at take-off)

$$a_1 = (V_2 - V_1)/\text{groundtime} \qquad (9)$$

where a_1 = the X-acceleration over the entire time on the ground.

$$F_1 = m * a_1 \qquad (10)$$

where F_1 = the X-force from the entire time on the ground. This assumes that the force was constant throughout the entire time while in contact with the ground.

For the vertical forces, the assumption was made from Smith (1983) that the force was accelerating the body from a position of zero velocity. This point was the low point for the C of G while on the ground, since the body was slowing down the descent, then pushing to provide lift. The problem here was that the force to provide the braking effect was not considered. Thus, a normal Y-force curve which shows two peaks cannot be derived. The two peaks from the normal force curve show the braking force and the lift force. The Y-force was viewed in this equation as occurring from the low point of the C of G until take-off occurs.

The variables and equations for the Y-force from Smith (1983) are:

T = airtime

$$T/2 = \text{ascent time} = \text{descent time} \qquad (11)$$

(Note that this assumed that the C of G started and finished at the same height.)

$$H = 1/2 * g * (T/2)^2 \qquad (12)$$

where H = the calculated height that the body should rise after take-off, and g = the acceleration due to gravity (9.8 m/s^2). Heights were also derived from film analysis for the heights of the C of G at take-off, landing, and at maximum height. A comparison of height up, height down and calculated height has also been made to see how well the technique by Smith (1983) represented the actual height attained. The height up was the difference in height of the C of G from take-off to the maximum height attained in flight. The height down was the difference in height from the maximum height to the landing position.

$$V_3 = g * (T/2) \qquad (13)$$

where V_3 = the vertical velocity at take-off. This was derived from the method of projectile motion since only the force of gravity was acting on the body while it was in the air. The velocity was required at take-off and then slowed to zero at the top of the parabola.

t_2 = force time

-the time from the instant at which the C of G was at its lowest until take-off

This was now utilizing the force-time = change in momentum formula:

$$F_2 * t_2 = m * (V_3 - V_0) \qquad (14)$$

where $V_0 = 0$ since this was the point where the C of G halts its downwards motion, and begins to rise.

$$a_2 = (V_3 - V_0)/t_2 \qquad (15)$$

where a_2 = the vertical acceleration at take-off. Note that this was an average acceleration over the entire force time.

$$F_2 = m * a_2 \qquad (16)$$

where F_2 = the Y-force. Since the acceleration used in the calculation was averaged, the result was that the force was also an average force for this time interval.

Since an average force omits all peaks and valleys, if an instantaneous force analysis was shown as well, the expectation is to have peak forces much in excess of this average force.

Centripetal Force.

The centripetal force at take-off was also calculated using formulae from Smith (1983). This centripetal force could be thought of as the force that the body has directed away from the axis of rotation due to the angular velocity of the body during this phase. In order to procede with this calculation, it was necessary to compute the contact and take-off angles. This was done by utilizing equation (4) as already stated. The average angular velocity was found via the following steps:

$Angle_1$ = angle of the body at contact

$Angle_2$ = angle of the body at take-off

$$W = (Angle_2 - Angle_1)/groundtime \qquad (17)$$

where W = the average angular velocity, and the angles are measured in radians from the horizontal. The radius was considered to be the average distance from the C of G to the toes, which were considered to be the pivotal point. This was assumed since the actual pivotal point probably shifts along the foot while it was in contact with the ground. Note that the radius also changes due to flexion and extension of the hips, knees and ankles throughout the ground time. Now the centripetal force could be calculated with:

$$C.F. = m * W^2 * r \tag{18}$$

where C.F. = the centripetal force

m = the mass of the subject

W = the angular velocity of the body

r = the radius of rotation from the toes to the C of G

Determination of Angular Momentum

The relationship between the angular velocities of the body segments was determined. These velocities enabled the calculation of angular momentum to be attempted by utilizing the body segment moments of inertia about the transverse axis of each segment, and then summing the segmental angular momenta.

The angular momentum of the subjects about the transverse axis was calculated by employing the radii of gyration developed by Plagenhoef et al. (1983). The formula was one reported by Hay et al. (1975) whereby a summation of the momentum of the masses about their individual C of G's and a transferred moment about the body's C of G was performed. The formula is:

$$M = \sum_{i=1}^{14} (I_i w_i + m_i r_i^2 w_i^*) \qquad (19)$$

where M = the angular momentum of the entire body; m_i = the mass of segment i; I_i = the transverse moment of inertia of segment i; w_i = the angular velocity of segment i about its transverse axis; r_i= the projected distance between the C of G of segment i and the C of G of the entire body; and w_i^* = the angular velocity of the C of G of segment i about the C of G of the whole body.

The moments of inertia for the segments were found from the equation

$$I_1 = m_1 k_1^2 \qquad (20)$$

where I_1 = the moment of inertia for the segment about its own proximal joint, m_1 is the mass of the segment and k_1 is the radius of gyration of the segment.

Statistical Analysis of Data

A multiple series of t-tests on approach movement, performance level, and sex of the subjects were computed. Contact and take-off angles, and velocities were observed in order to determine any significant differences between the test conditions. Means of each condition, group, and sex was computed for angle of contact, total time of contact, and take-off angle. Also, data was analyzed in terms of force production as a function of body weight for each group.

A dependent t-test for small group sizes was computed for the data to see if there were any significant differences between the somersaults when performed from the handspring approach and the running approach. The dependent test was utilized, since the same subjects had to perform both of the skills. The test was conducted for the male group, female group, and the combined group.

Independent t-tests were also performed to identify any significant differences in male-female populations, and to determine differences in good vs poor performances. The independent tests were used here, since there were different subjects in each group. The computer programs for both dependent samples and independent samples are found in Appendix B.

RESULTS AND DISCUSSION

Kinematic Analysis

Positional and Temporal Analysis

The two positions that were examined most closely were that of contact and take-off. Contact was the instant that the feet touch the ground after the hurdle, while take-off was the instant that the feet leave the ground to go into the somersault. The body positions at these two times was considered to be critical. The means and standard deviations are shown in Tables 4, 5 and 6 . Note that in all cases, the contact angle was larger for the handspring to the somersault than for the running somersault. This indicates that the feet are placed further in front of the C of G due to the type of approach for the handspring. Thus, a closer to vertical position was the case for the running front somersault.

Table 4 is interesting to note from a coaches point of view. Although the males and females are compared, the result was that only one item was significantly different. That factor was ground time for the handspring at the .05 level of confidence from a t-test score of 2.981. This would seem to indicate that both the males and females have a similar motion in these skills.

TABLE 4

Positional and Temporal Data Male to Female

Variable Name	Mean Male N=7	S.D.	Mean Female N=6	S.D.	t-test score
Contact Angle Somi(radians)	1.964	.062	1.993	.055	-0.867
Contact Angle Handspring(rad)	2.151	.052	2.111	.067	1.208
Take-off Somi Angle(rads)	1.513	.049	1.509	.086	.106
Take-off Hdsp Angle(rads)	1.674	.099	1.645	.072	.598
Ground Time Somi (sec)	.130	.024	.116	.013	1.237
Ground Time Handspring(sec)	.164	.022	.132	.016	2.981*
Force Time Somi (sec)	.084	.011	.078	.005	1.257
Force Time Handspring(sec)	.097	.013	.088	.010	1.391
Air Time Somi (sec)	.614	.044	.582	.050	1.235
Air Time Handspring(sec)	.597	.060	.580	.042	.583

Note: t-value for .05 confidence level was 2.20*
for .01 confidence level was 3.11**

As well this larger angle occurred on the take-off, so that the body was not yet at the vertical for the handspring to front somersault, as shown in Table 6 . The mean angle

TABLE 5

Positional and Temporal Data Good vs Poor

Variable Name	Mean Good N=9	S.D.	Mean Poor N=4	S.D.	t-test score
Contact Angle Somi (radians)	1.976	.057	1.981	.072	-0.125
Contact Angle Handspring (rad)	2.141	.062	2.085	.012	1.238
Take-off Somi Angle (rads)	1.528	.058	1.473	.072	1.477
Take-off Hdsp Angle (rads)	1.670	.088	1.606	.052	.973
Ground Time Somi (sec)	.114	.009	.145	.024	-3.468**
Ground Time Handspring (sec)	.152	.027	.135	.070	.854
Force Time Somi (sec)	.080	.009	.085	.010	-0.939
Force Time Handspring (sec)	.094	.012	.090	.014	.386
Air Time Somi (sec)	.615	.039	.565	.053	1.906
Air Time Handspring (sec)	.596	.053	.550	.014	1.194

Note: t-value for .05 confidence level was 2.20*
for .01 confidence level was 3.11**

of take-off for the running front somersault showed a position past vertical for all groups. The general trend would appear to agree with the principle of ground reaction forces, in that the better somersaults had a smaller ground time while a longer time in the air resulted, (Hay, 1975). Note that the ground time for good vs poor performances was significantly different at the .01 level of confidence, with a t-score of -3.468 as shown in Table 5

Thus, the expectation would be that the better performers would have to exert a much larger force over a smaller period of time. This larger force creates a higher velocity, which enables the performer to stay airborne for a longer period of time. These trends are noticeable when comparing either of the somersaults with the performance levels, and also when comparing the running somersault to the handspring front somersault.

The only exception was in comparing the males to the females, in Table 4 . Here the ground time for females was shorter but so is the air time. If the force time was noted however, it would appear that the males spend a greater portion of the time braking the downward velocity from the hurdle. Whether this was due to a greater mass or a different muscle type and slower reaction time was not known, but both could have an effect on this time difference. The force times for both groups were very close after the braking factor had been considered.

Figures 3 and 4 show the computer tracings of one of the subjects for the contact and take-off positions. The running front somersault was illustrated in Figure 3 . Note

TABLE 6

Positional and Temporal Data Somersault vs Handspring

Variable Name	Mean Somi N=13	S.D.	Mean Handspring N=13	S.D.	t-test score
Contact angle (radians)	1.978	.059	2.133	.061	5.709**
Take-off Angle(radians)	1.511	.065	1.660	.085	7.460**
Ground time (seconds)	.124	.021	.149	.025	3.757**
Force time (seconds)	.081	.009	.093	.012	7.137**
Air Time (seconds)	.599	.048	.589	.051	1.229

Note: t-value for .05 confidence level was 2.18*
for .01 confidence level was 3.06**

the flexed joints of the hips, knees and ankles at contact. This flexion indicates that the gymnast was preparing to extend the joints immediately on contact. Since there was some forward and downward velocity, the first forces will be braking forces to reduce the downward velocity to zero. This action will further flex the joints mentioned, causing a gain in elastic energy in the extensor muscles. At the lowest point of the C of G, the joints will begin to extend and will continue to do so until the take-off position has been reached.

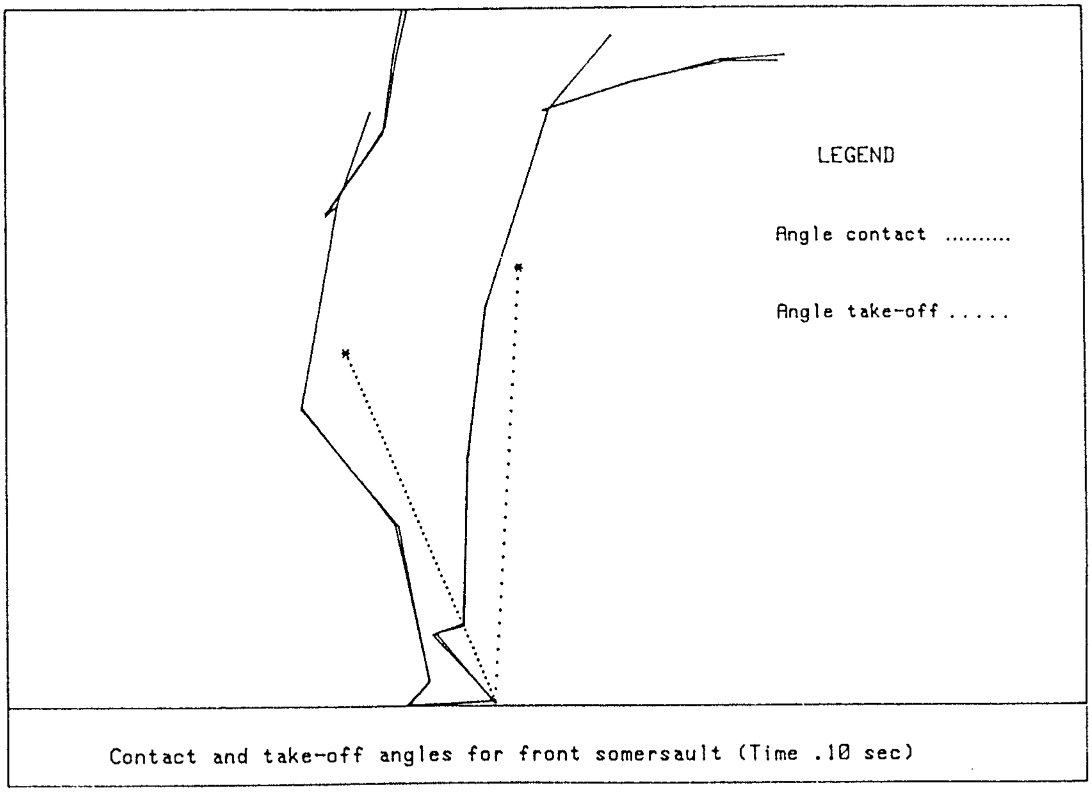

Figure 3: Contact and take-off for the front somersault

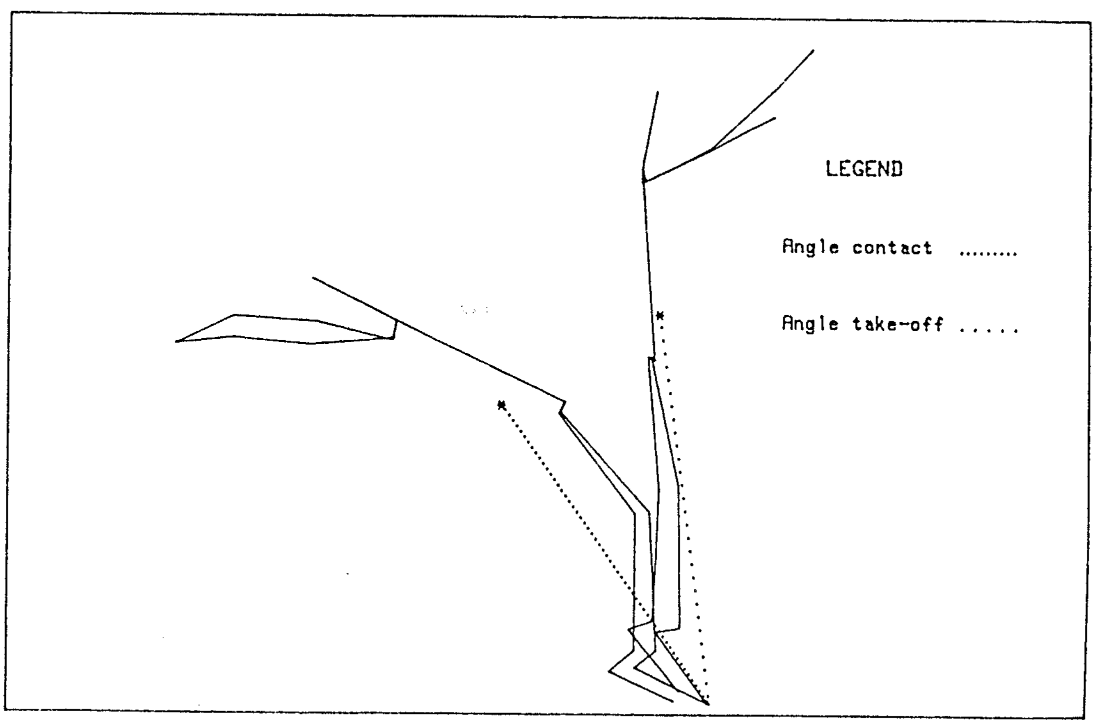

Figure 4: Contact and take-off for the handspring to somersault

The key point here was that the time interval between these two positions averaged 0.124 seconds for all the somersaults performed. Thus, the motion was strictly an extensor thrust mechanism. In coaching, the importance here will be to attune the gymnast to this fast reaction of the extensor muscles.

The handspring, as shown in Figure 4, indicated a position of greater backward lean at contact. In order to achieve a proper take-off angle, there was a requirement for a larger transition angle for some body parts. This transition angle was necessary to place the total body in an appropriate position for take-off, so that forward rotation and forward motion would occur. As well, the time on the ground for the handspring averaged 0.149 seconds and could allow a slightly greater movement with a longer time on the ground.

Another major factor for slowing down the ground time for the handspring could be the ineffective position of the hip angle at contact. For most gymnasts the hips were in a hyper-extended or arched position at contact. The motion was then one of flexing the ankles and knees, while the upper body moved forwards so that the hips also became flexed. This increased flexion could increase the amount of elastic energy stored in the hip extensors, since they are being stretched over a greater distance. However, the initial motion would merely bring them back to a normal position from the hyper-extended position, so the additional stretch was a questionable area.

Figure 5 shows the ground time positions for a front somersault. From Figure 5, one can see the flexion of the ankles, knees and hips in a sequential manner, then the reverse of this order for the extension phase. Figure 6, the airborne phase of the somersault shows the rotation of the body about the C of G. Thus, while the parabolic motion of the C of G was set at take-off, the body undergoes a number of changes. These changes in body shape as it moved into a tuck position cause a reduction in the moment of inertia since the mass was moving closer to the mass center. The other effect that tucking had on the motion, was to increase the angular velocity of the rotation. The increased angular velocity with a reduced moment of inertia were a trade off because the total angular momentum of the body is always constant while in the air, (Hay, 1974).

The angular inclination of body parts which showed a statistical difference are shown in Table 7 . At a 0.01 probability level, the t-test score required was 3.06. Note that all the upper body segments achieved this significant difference between the two skills. There was a visible difference in the approach position for the two movements. For the running front somersault, the body entered at an angle much closer to vertical than for the handspring to front somersault. Since the body is in a more vertical position

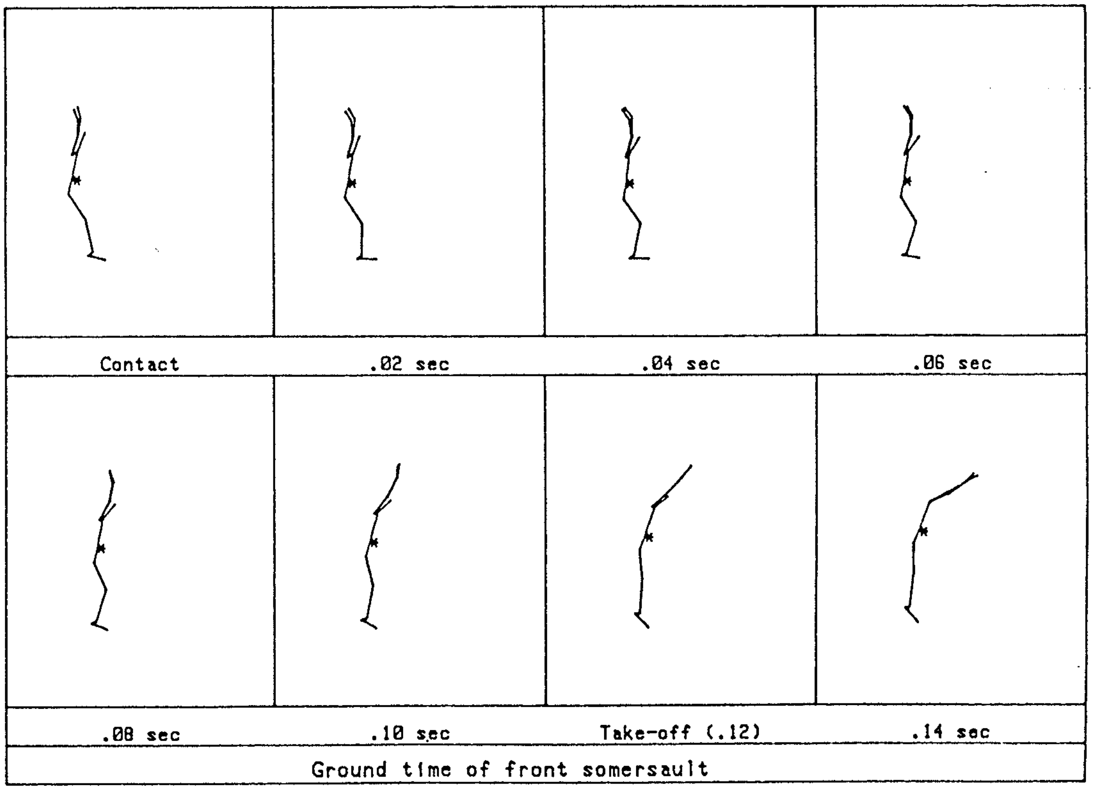

Figure 5: Ground time of a front somersault

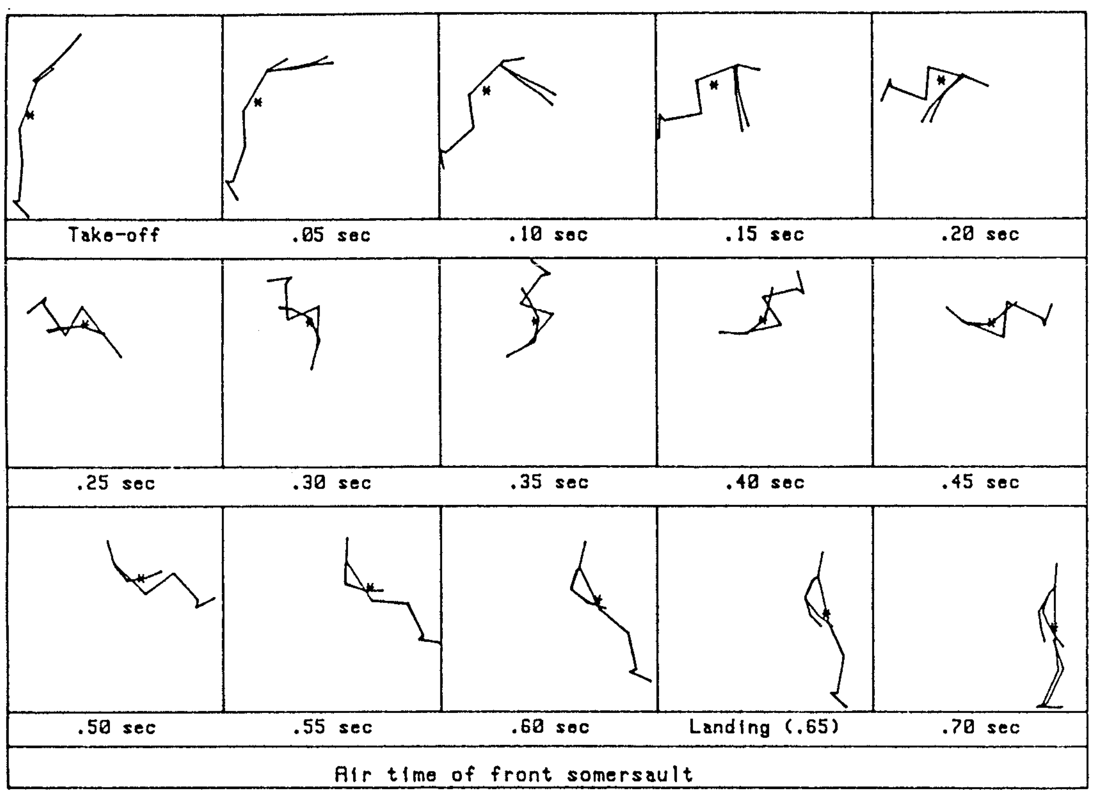

Figure 6: Air time of a front somersault

for the running front somersault, the time on the ground needed to reach the take-off angle was less. This allowed for a faster reaction time in the legs and thereby a shorter

TABLE 7

Angular Inclinations of Body Parts at Contact

(radians)

Body Part Variable	Mean Somi N=13	S.D.	Mean Handspring N=13	S.D.	t-test score
Whole body	1.978	.059	2.133	.061	6.585**
Upper arm	1.079	.188	2.933	.419	3.717**
Head	1.327	.170	3.035	.339	3.648**
Trunk	1.321	.128	2.573	.151	3.566**

Note: t-value for .05 confidence level was 2.18*
for .01 confidence level was 3.06**

ground time for the front somersault.

Angular Velocity

The angular velocity of the body and body parts is reported in Table 8 . While the handspring performances traversed a greater angle during ground time on the average, the somersault performances had a larger angular velocity. This was a direct result of a shorter ground time for the somersault. For the trunk, arms and head, the angular velocity was greater for the handspring during this time interval. Note that this was necessary since the handspring went from a position of hyper-extension to one of flexion. The means and standard deviations for the angular velocities of the whole body, and the three body parts listed above are shown

TABLE 8

Angular Velocity of Body and Parts During Ground Time

(radians/sec)

Body Part Variable	Mean Somi N=13	S.D.	Mean Handspring N=13	S.D.	t-test score
Whole body	3.842	.610	3.192	.486	3.001*
Upper arm	5.875	2.164	15.860	5.229	3.596**
Head	3.430	1.565	10.355	2.917	3.078**
Trunk	1.355	.898	6.668	1.182	3.407**

Note: t-value for .05 confidence level was 2.18*
for .01 confidence level was 3.06**

in Table 8 .

Since the handspring has greater angular velocities for the upper body during ground time, there must be an additional amount of energy expended by the body in creating this faster motion, or a larger angular momentum present from the handspring. If the gymnast does not have the strength or power to cause this motion, then they would have a longer ground time to allow for this transition to occur.

Distances Travelled

Other elements which were analyzed were the height and distance travelled by each group for each type of somersault. Again, the data was compared by sex, type of somersault approach, and by performance level. There were significant differences shown statistically by independent t-tests, and paired t-tests. Trends were noticeable, with the running somersault having a shorter ground time, but a longer air time on the average. The probable outcome would be that the running front somersault would travel both higher and further. Table 9 shows the means and standard deviations for the heights and distances calculated for the somersaults, and the significance of these trends is also reported.

From Table 9 it was noted that the average heights and distances travelled were larger for all cases for the running front somersault than for the handspring. This agreed with the prior assumption that a larger air time would result in a greater height achieved and distance travelled. The only height which was greater for the handspring than for the somersault was while the feet were in contact with the ground. This was a reasonable result due to the more

TABLE 9

Heights and Distances of Somersaults

Measured Variable	Mean Somi N=13	S.D.	Mean Handspring N=13	S.D.	t-test score
Height C of G rises from take-off (m)	.328	.077	.293	.085	2.690*
Height C of G falls till landing (m)	.491	.061	.469	.066	1.658
Calculated height from Smith(1983)	.443	.070	.428	.075	1.211
Change of height C of G at ground time low point to take-off (m)	.180	.027	.223	.040	5.278**
Distance C of G during air time (m)	1.782	.226	1.229	.196	6.685**
Distance Rtoe during air time (m)	2.195	.291	1.431	.318	6.842**

Note: t value for .05 probability was 2.18*
for .01 probability was 3.06**

vertical body position. For the handspring, the C of G was actually located behind the body due to the hyper-extension of the trunk and legs on contact. Therefore, the C of G would be closer to the ground than for a more upright approach as in the running front somersault. Thus, the C of G had a larger distance to rise while the feet were still in contact with the ground. The visual effect would be one of observing the C of G position moving a greater vertical distance provided that both somersaults achieved the same height. This could lead to a more aesthetically pleasing performance, and lead to an increase in judges scores for this visual effect.

The measurement for changing the height of the C of G while in contact with the floor is shown in Figures 7 and 8 The lowest point for the C of G during ground time was recorded. This was the position when the vertical velocity was zero. The interval from contact to this position was the braking interval. From the low point till take-off was the force time used for calculations by Smith(1983). The Y-velocity was increasing, after the low point had been reached, to achieve take-off velocity.

Note that the change of height for the somersault was significantly less than that of the handspring. Table 9 shows a t-score of -5.278 from a dependent t-test, which is significant at the .01 level.

Figures 9 and 10 show the measurement positions for the other heights and distances. The diagrams have the take-off position, the frame showing the highest C of G, and the landing position outlined. The lines indicated that in general, the C of G fell further than it rose between the two

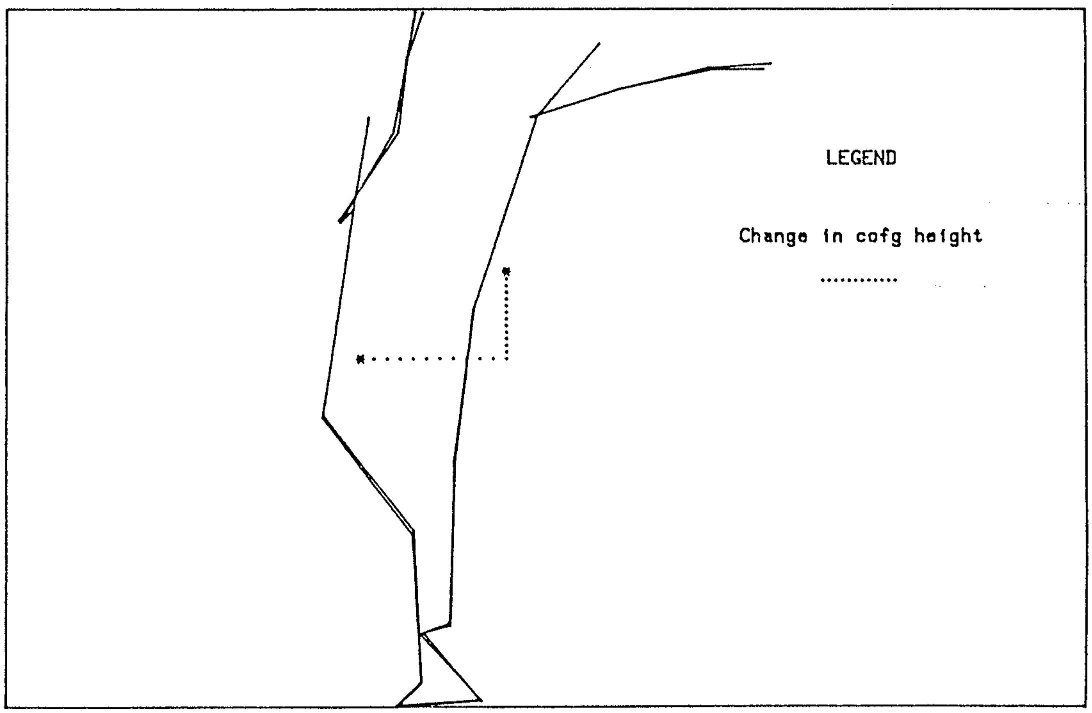

Figure 7: Ground time change of height for somersault

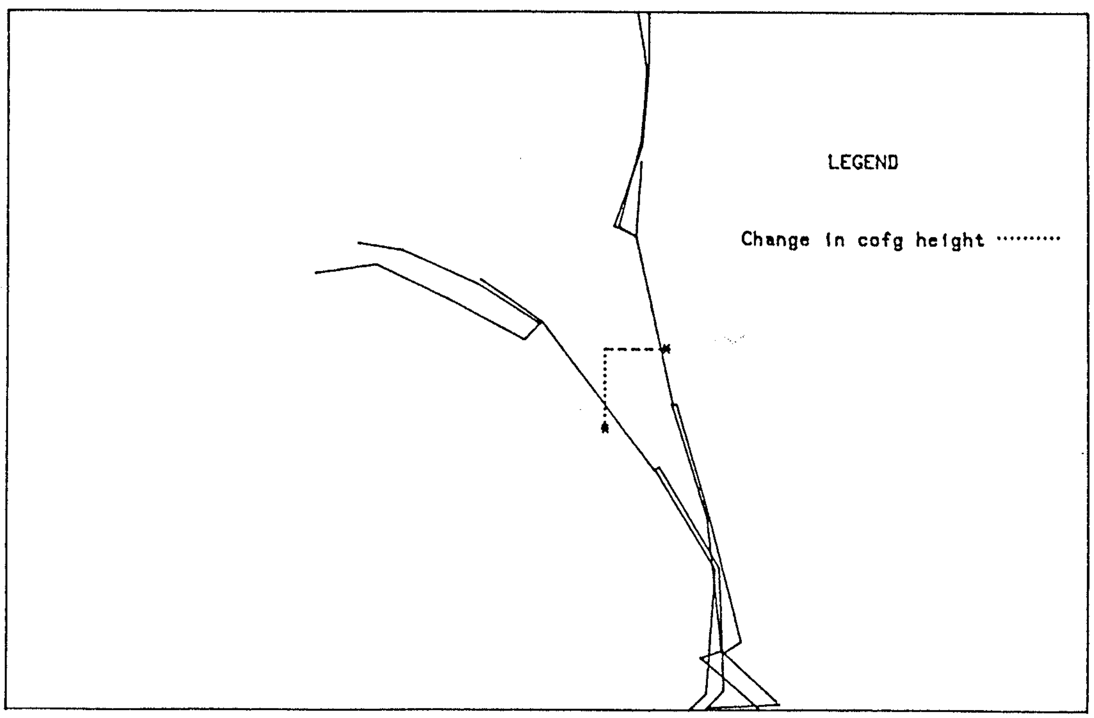

Figure 8: Ground time change of height for handspring

foot contact positions. On take-off, the athlete was extending all joints to project the body into the air. Yet, on landing, the preparation was being made to absorb the energy of the fall. The result was that the hip and knee joints were slightly flexed, which would lower the C of G on landing. Note that Smith(1983), from Table 9, has a predicted height which was between the rising and falling heights. The height for the running front somersault was significantly different from the handspring only for the rising height, and then only at the .05 level.

The horizontal distances travelled for both the C of G and the right toes was significantly more for the running somersault. It was interesting to note that the C of G and right toes did not travel the same horizontal distance during this time interval. The reason for this difference became apparent when the take-off and landing positions were traced. With the body angled at both times, the feet were forced into a greater distance movement.

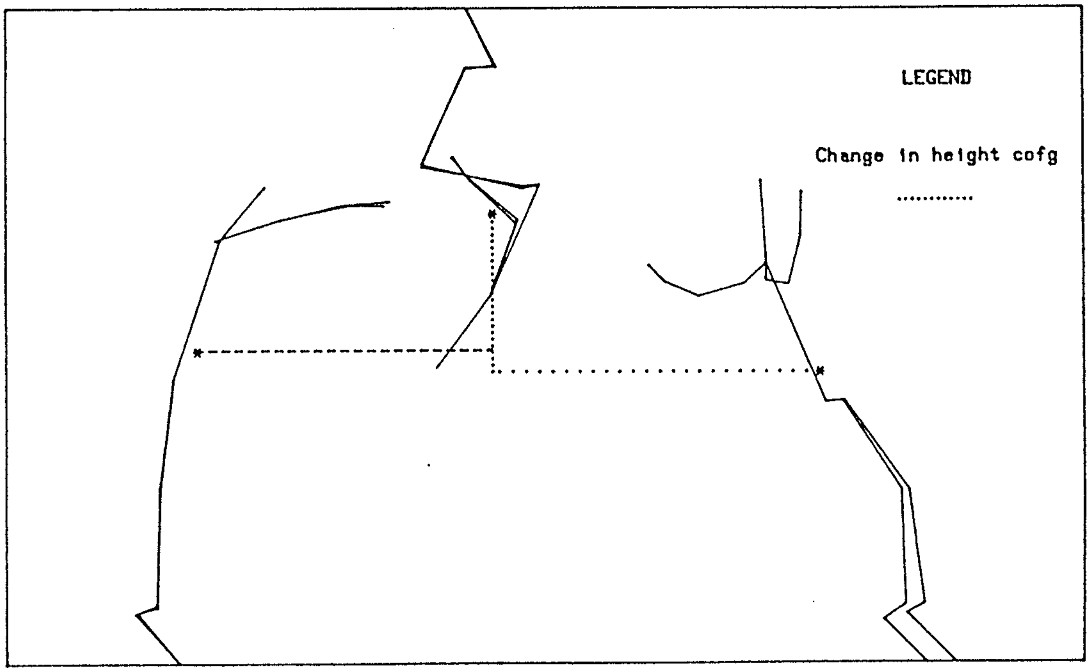

Figure 9: Positions for heights and distances - Somersault

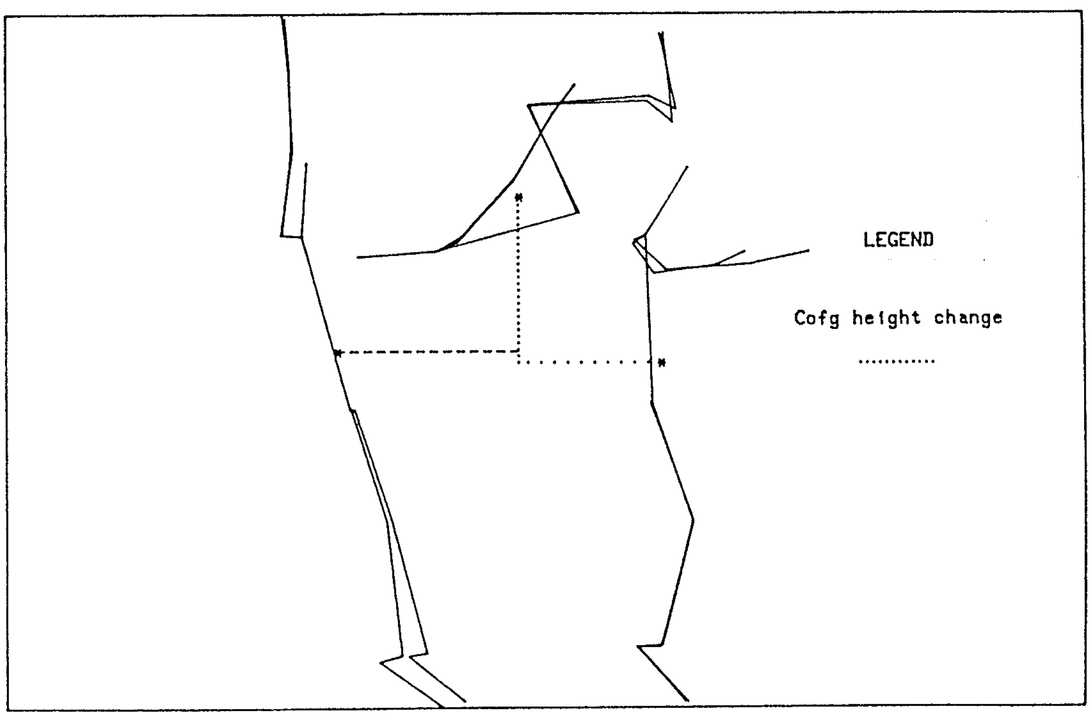

Figure 10: Positions for heights and distances - Handspring

Body Trajectory

Figure 11 shows the different parabolic trajectories for different body parts. Note the C of G appeared to have a longer and flatter trajectory than did either the hips or the feet. This is the effect of additional motion in the air for the hips and feet, while the C of G has been set

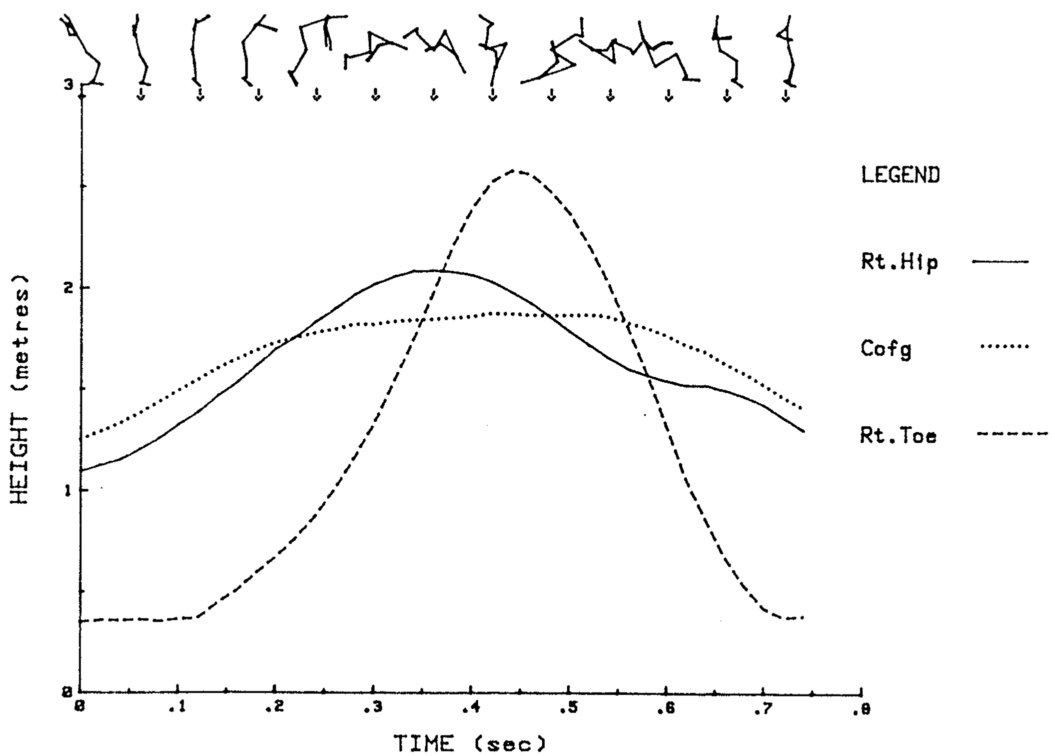

Figure 11: Trajectories of body parts

from take-off.

Linear Velocity and Acceleration

After these initial studies on heights and distances was complete, the next factor to consider was the velocity of the body at various times. Since the film was taken at 100 frames per second, the time between frames was 0.01 seconds. The important times to consider for the horizontal and vertical velocities were the time before contact, and the time at take-off. These are reported in Table 10 . With these velocities it would be possible to further compute the accelerations that occurred during ground time.

The velocity in the X-direction suggested that there was a slowing effect while on the ground. Therefore, the acceleration for the overall ground time would be negative. Table 10 shows that while there were statistical differences from the t-test values, the average for the X-velocity at contact and take-off appears to be higher for the somersault than for the handspring somersault. This appeared to be logical since the running approach would have no prior braking effect as was evident with the handspring when the hands were placed on the floor.

The Y-velocity at take-off showed no significant difference between somersaults, so the subjects appeared to generate the same energy into each somersault for vertical lift. Since the mass of the body did not change between trials, and the change in vertical velocity was the same, then the change in vertical momentum would be the same.

TABLE 10

Velocities and Accelerations of Somersaults

Calculated Variable	Mean Somi N=13	S.D. S.D.	Mean Handspring N=13	S.D.	t-test score
X-velocity at contact(m/s)	5.046	.354	3.623	.464	8.910**
X-velocity take-off(m/s)	2.971	.276	2.100	.367	7.214**
Y-velocity take-off(m/s)	2.937	.235	2.887	.252	1.229
Horizontal acceleration (m/s^2)	17.34	4.75	10.38	4.35	4.564**
Vertical acceleration (m/s^2)	36.51	4.96	31.64	6.11	4.126**

Note: significance level .05 for t-score 2.18*
.01 for t-score 3.06**

However, if the time factor was taken into consideration, to observe how long the subject had to change the velocity, then another pattern arose. The ground time for each subject's front somersault was less than or equal to the time for the handspring. The same was true for the time when the force was propelling the body upwards. Thus, the gymnast would have to arrive at this final velocity over a shorter period of time. Therefore, the acceleration in the Y-direction for the running front somersault was significantly greater than that for the handspring.

The combination of rapid change of velocity over a short period of time had a significant effect in increasing the horizontal, (X), acceleration. The t-test score of 4.564 between all 13 somersaults and all 13 handspring front somersaults was significant at the 0.01 probability level as shown in Table 10 . Thus, there appeared to be a significant difference in the X-acceleration between the running front somersault and the handspring front somersault. As a coach, the idea of "blocking" more on the front somersault would be emphasized. The attempt to transfer more of the horizontal momentum into vertical momentum and rotation by the blocking action was a logical outcome. For the handspring front somersault, the action was less of a blocking effect, and more of an attempt to move the upper body rapidly into take-off position as was shown in the results in Table 8 .

Kinetic Analysis

Since the method utilized by Smith(1983) described only an average force, then a force curve could not be derived. Otherwise the curve would simply be a horizontal line indicating constant force for the duration of the force time. The other method which showed the instantaneous forces throughout the performance was used to produce data which when plotted resembled the usual force curves.

A correlation was conducted between the peak Y-force values as derived from the smoothed data for the instantaneous forces and the Y-force values from the averaged method. As Table 11 showed, there was a high correlation between all groups studied. Thus although the forces were obviously different from the two methods, they tended to indicate a similar pattern for ranking the forces produced by the gym-

TABLE 11

Correlation Between the Two Y-Force Methods

Method	(Newtons) Mean	S.D.	r
Average Force Male somi N=7	2124	804	
			.79
Peak Force Male somi N=7	5147	2277	
Average Force Female somi N=6	1325	263	
			.94
Peak Force Female somi N=6	2888	760	
Average Force All somis N=13	1643	705	
			.81
Peak Force All somis N=13	3662	1921	

nasts.

The averaged forces were statistically analyzed. Both independent and paired t-tests were computed for comparing male to female, good to poor performances, and approach movement differences. Table 12 shows the results of these analyses for the Y-forces and the centripetal forces. The centripetal force was the result of the body pivoting about the toes while in contact with the floor. The major significant differences occurred between the two types of movements. The paired t-tests indicated that the somersault and the handspring generated significantly different vertical forces and centripetal forces for the combined group. The boys were also significantly different, but only at the .05 confidence level, as were the girls for centripetal force. It was only when the groups were combined that the sample size became large enough to note the difference at the .01 level. This was one of the continuing difficulties with small sample sizes and a fairly homogeneous group. All of the gymnasts were reasonably skilled, so that statistical differences became difficult to obtain.

The only other significant difference was for the male to female somersault comparison. This indicated that the males vertical force was significantly more than the females, but again only at the .05 level of confidence.

TABLE 12

Comparison of Averaged X and Y-Forces, Centripetal Forces and Resultant Force:Body Weight

(Newtons)

Variable Name	Mean Somi	S.D.	Mean Handspring	S.D.	t-test score
Y-Force Male (N=7)	2125	801	1830	823	2.790*
Y-Force Female N=6	1325	263	1183	295	2.383
Y-Force Both groups N=13	1756	722	1532	698	3.456**
Centripetal Force Males N=7	702	229	473	130	3.285*
Centripetal Force Female N=6	534	120	400	77	2.649*
Centripetal Force All N=13	624	199	439	111	4.150**
X-Force Both groups N=13	791	251	516	358	4.326**
Average (N=13) Resforce:bdw (bdw=body weight)	4.14	.556	3.41	.691	4.766**
Peak (N=13) Resforce:bdw	8.55	2.03	6.70	2.24	3.105**

Note: t-value for boys at .05 was 2.45*
.01 was 3.71**
for girls at .05 was 2.57*
at .01 was 4.03**
for both at .05 was 2.18*
at .01 was 3.06**

The Y-force curves produced by plotting the instantaneous forces are shown in Figures 12 and 13 They both showed an initial braking force which was the first peak. This was the force that was reducing the downward motion of the C of G. The second peak is the region where the legs were extending, to push the body into the air. Noting the heights of the peaks, a comparison was made between the peak vertical force and the average vertical force relative to the body weight of the subject. The averaged resultant force was found to be about 4.14 times body weight for a somersault, and 3.41 times body weight for a handspring. These were significantly different from each other at the .01 confidence level with a t-score of 4.726 for the 13 subjects, as shown in Table 12 . The peak forces on the other hand, indicated mean measures of 8.55 times body weight for the somersault and 6.70 times body weight for the handspring. Again, these were significantly different from each other, and also different from the averaged forces. Also, it was noted that these peak forces were approximately two times the averaged force.

This was a rather large force which had to be exerted over a very brief interval. The forces from the instantaneous plots were in the same range as the forces found by Bruggemann(1983) for a back somersault. These impact forces were greater than other authors had determined for other moves, so an attempt was made to utilize a force plate to verify these forces.

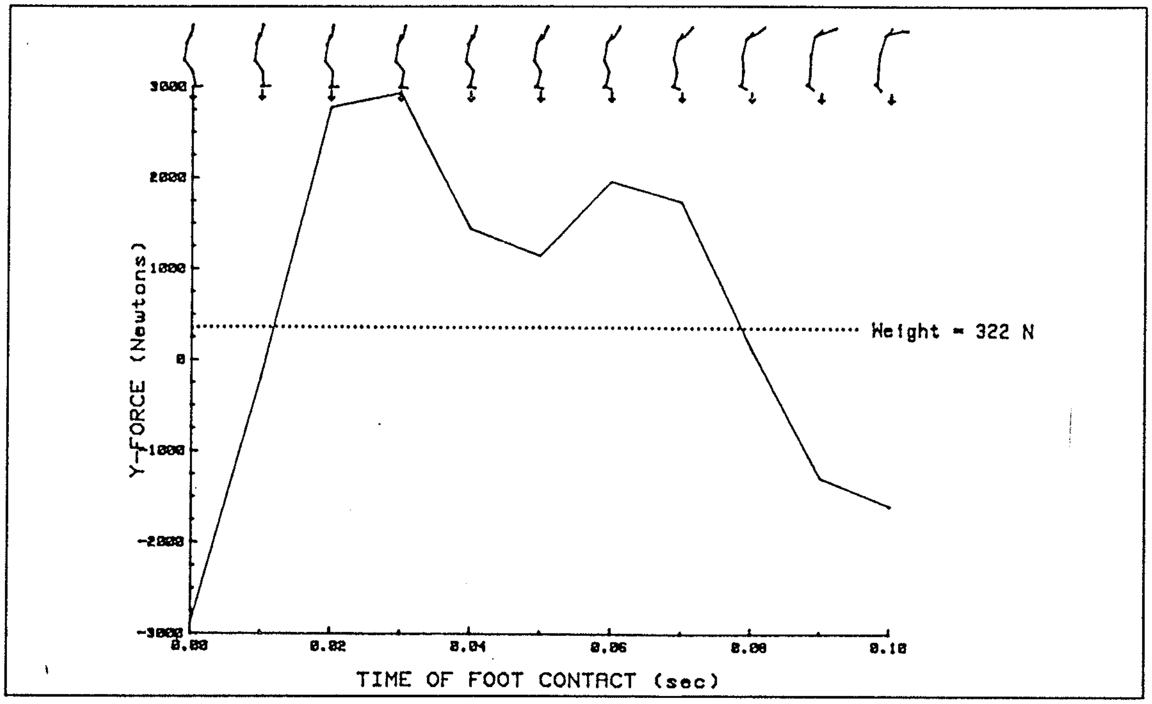

Figure 12: Y-forces in a front somersault

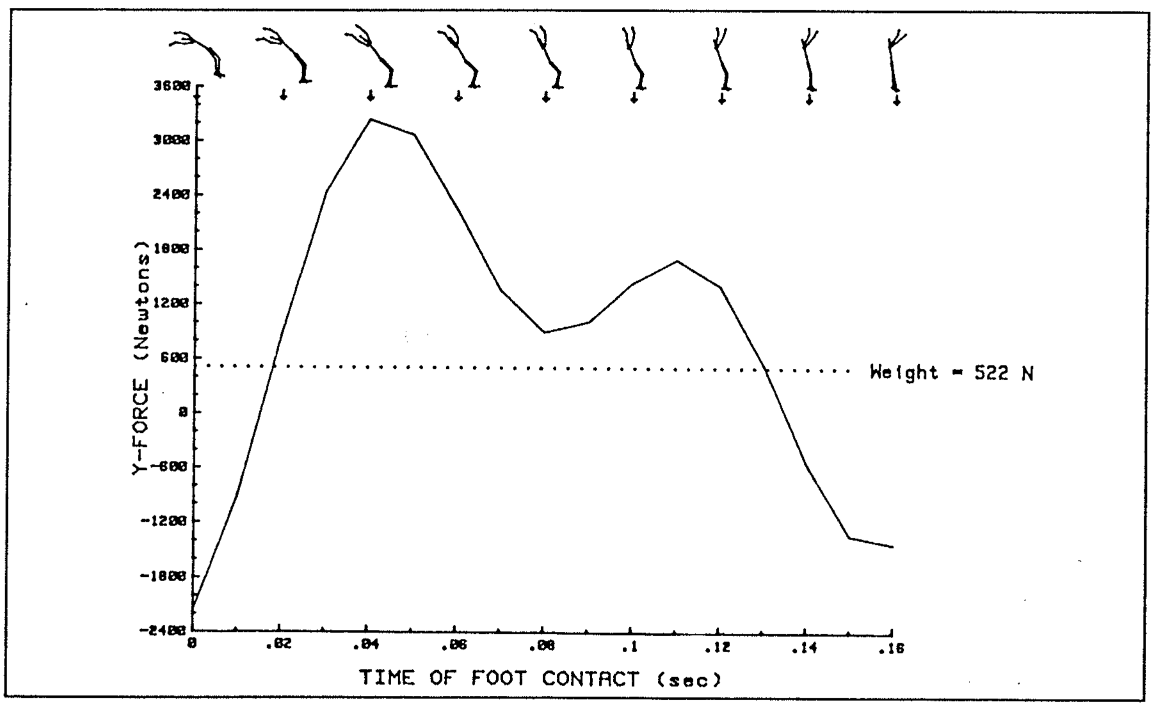

Figure 13: Y-forces in a handspring

Force Plate Trials

The trials on the force plate at the Engineering department at the University of Manitoba were carried out over a one month period. This author made four unsuccessful attempts to record data from this plate. The lightest subjects performed front somersaults from the plate. The first subject had a weight of 322 Newtons. Although the three supporting cables were capable of withstanding over 1100 Newtons each, the subject proceeded to snap all three cables. Through the various trials, which lasted over a one month duration, different arrangements were attempted, but in every case at least one cable would snap. Although this did not provide actual data, it did reinforce the idea that the force would be well over three times body weight.

With the horizontal forces, there were again two methods incorporated. The average force which was calculated for the entire ground time showed means of 791 Newtons for the somersault, and 516 Newtons for the handspring. These had a t-test score of 4.326 significant at .01, between them, indicating that there was a larger X-force for the somersault, as shown in Table 12 .

The instantaneous X-forces were plotted on Figures 14 and 15 They again showed significantly higher peaks than the averaged forces. Here there were interesting differences in the graphs comparing the front somersault and the handspring. While the peak X-forces were greater for the somersault than for the handspring which was similar for the averaged forces, the curves for the two moves do not have a similar shape. For the somersault, the curve changes from a braking force to a forward accelerating force, indicating that the C of G has passed in front of the angle of the force. The handspring on the other hand has a double negative peak. The first was a braking effect, while the second showed that the C of G was behind the force vector when the legs began to extend.

Factors which appeared to show significant differences between good and poor performances of a somersault performed from a running approach are found in Table 13 . The factors affecting the somersault are all associated with the ground time. An overview would indicate that the better performances have a larger amount of blocking, so that the X-acceleration is higher, a shorter ground time with a larger resultant force compared to body weight ratio. These culminate in allowing the better performances to have a higher C of G on rising. While a similar trend for the handspring approach was seen, none of the factors reached a significant level on the t-test scores for the handsprings.

There were no significant differences between males and females which were not influenced by either the height or mass of the subject. Thus, coaching points for both males and females would emphasize the same points as noted in distinguishing the good performance.

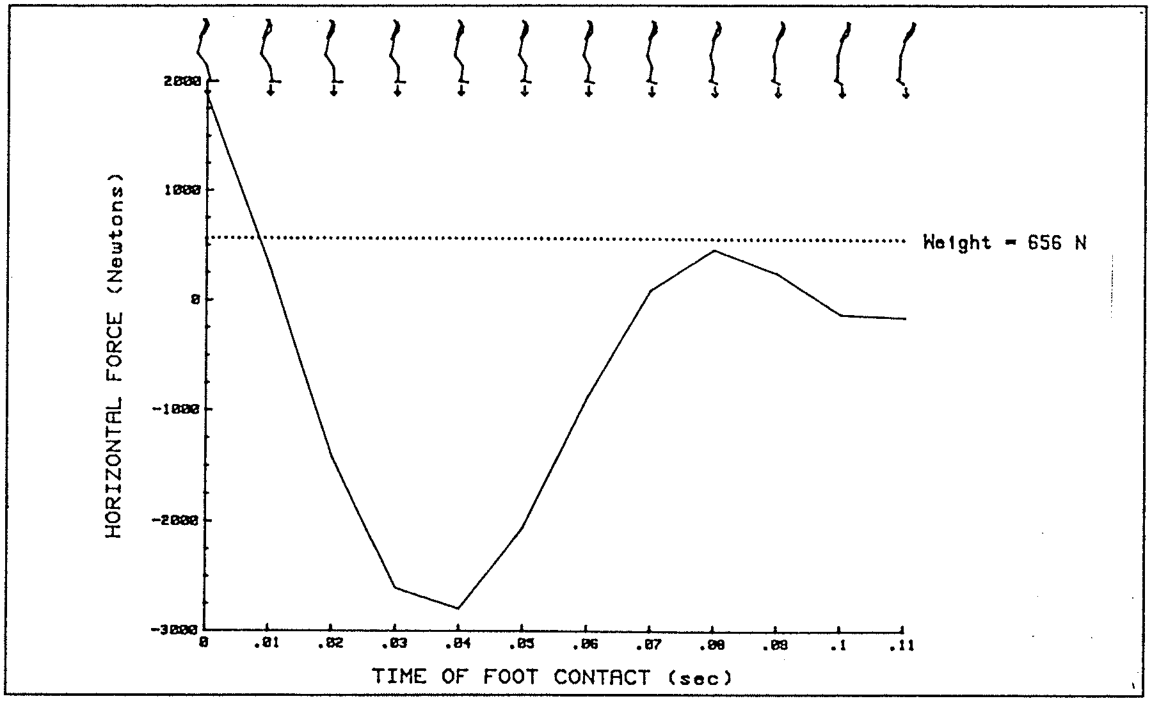

Figure 14: X-forces in a front somersault

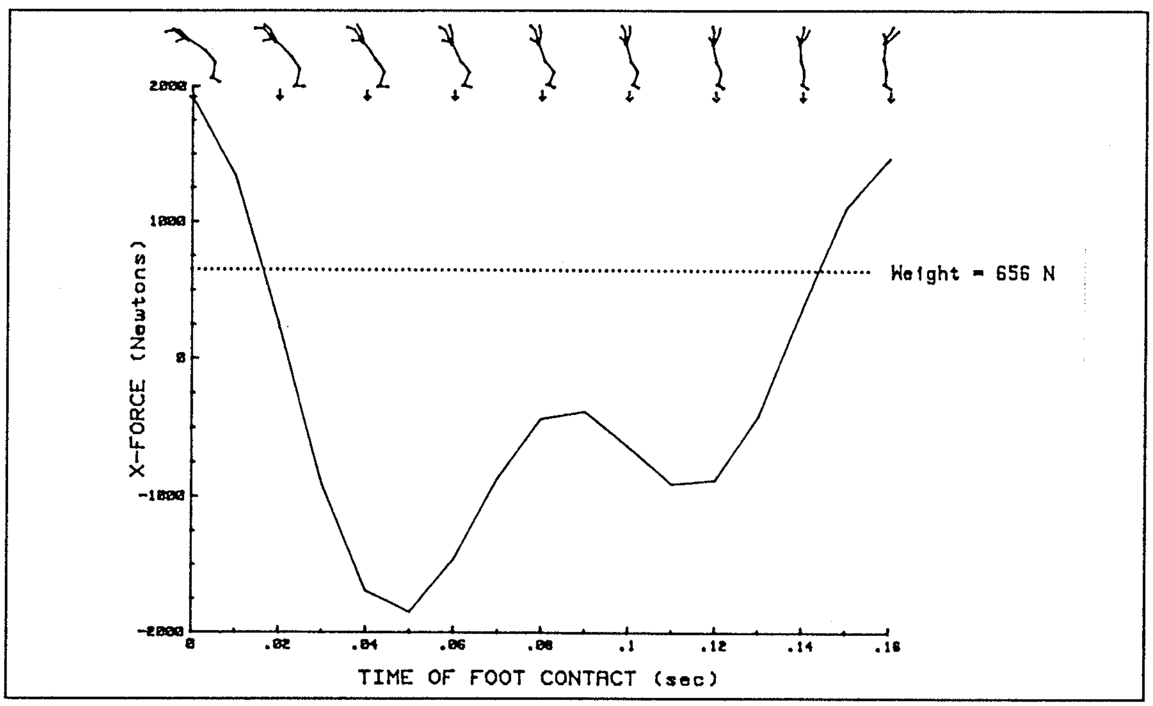

Figure 15: X-forces in a handspring

TABLE 13

Factors Affecting Performance of a Somersault

Variable Name	Mean Good N=9	S.D.	Mean Poor N=4	S.D.	t-test score
X-Acceleration (m/s^2)	19.08	4.34	13.43	3.26	2.306*
Ground time (seconds)	.114	.009	.145	.024	3.468**
Resforce:bdw (bdw=body weight)	4.365	.455	3.651	.462	2.599*
Maximum height C of G rises (m)	.369	.049	.237	.041	4.645**

Note: t-value for .05 confidence level was 2.20*
for .01 confidence level was 3.11**

Angular Momentum

The angular momentum during the flight phase of the somersault was computed using a Fourier transform, smoothing techniques, and a program as shown in Appendix B. A general view was that the angular momentum was set at take-off. While in flight, only the moment of inertia for the whole body and the angular velocity of the entire body could be changed. Note the inverse relationship between the two parameters. That was if one factor went up, then the other would go down in order to keep the equation:

$$M = I * W$$

in balance, where M is the angular momentum, I is the moment of inertia of the body, and W is the angular velocity of the entire body. The moment of inertia of the whole body in a stretched position was 15.12 $kg\text{-}m^2$ and for the tucked position it was 3.5 $kg\text{-}m^2$ as shown in Hay(1978). Thus a 4.3 fold increase could occur in the angular velocity when the body moved from a stretched position to a tucked position.

The angular velocity of the body was such that it was possible to rotate 360^0 or 6.28 radians during the time that it required for a somersault to occur. Note the mean air time for a front somersault was .599 seconds, while for the handspring to front somersault it was .589 seconds. Therefore the body had an average angular velocity of 10.5 radians/second for the somersault, and 10.7 radians per second for the handspring to front somersault. The angular momentum that was recorded by the computer program showed values around 160 $kg\text{-}m^2/sec$ for the somersault, and values near 190 $kg\text{-}m^2/sec$ for the handspring to front somersault. Note that if the average angular velocity was multiplied by the moment of inertia at take off, the value came within a 15% margin of the graphed value. A similar value can be shown when the average angular velocity was increased by 4.3 times, as the body tucked, then multiplied by the moment of inertia for the tuck position. Figures 16 and 17 showed the angular momentum graphs of a front somersault, and a handspring to front somersault. There was not a completely flattened effect for angular momentum, but within a 10% ratio the central portion of the curve does appear to be consistent at about 190 kg-m^2/second for the front somersault, while the handspring front was near 160 kg-m^2/second.

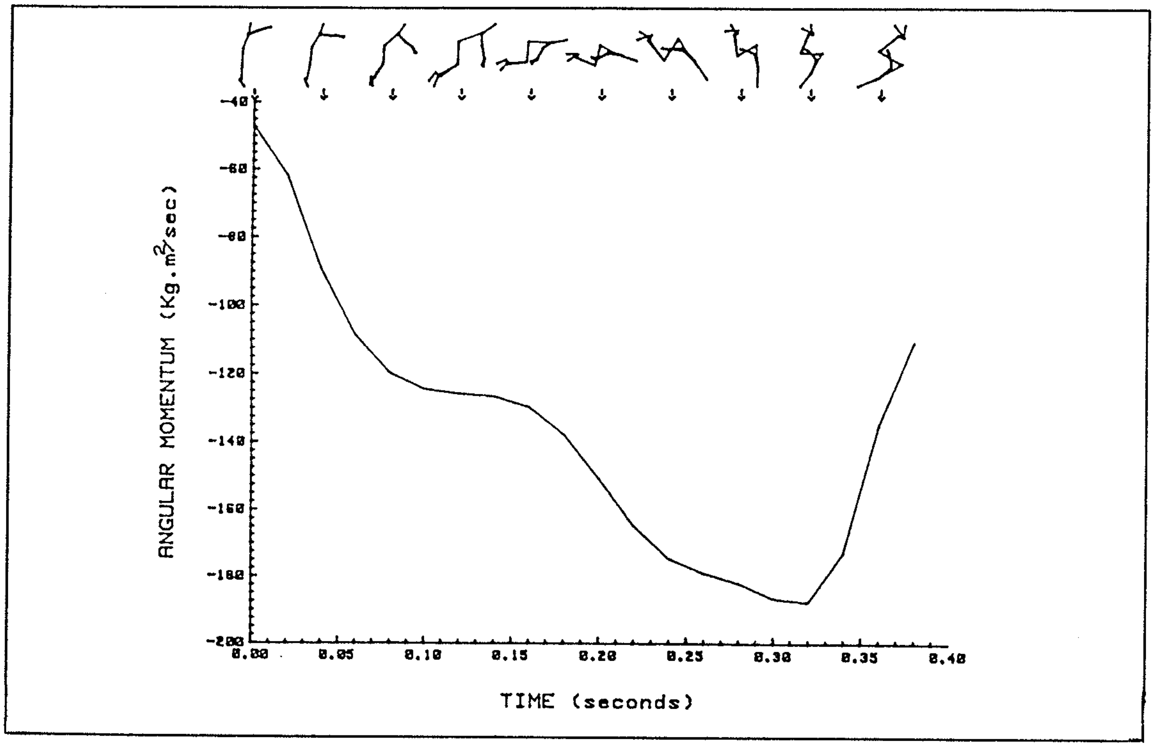

Figure 14: Angular momentum during a front somersault

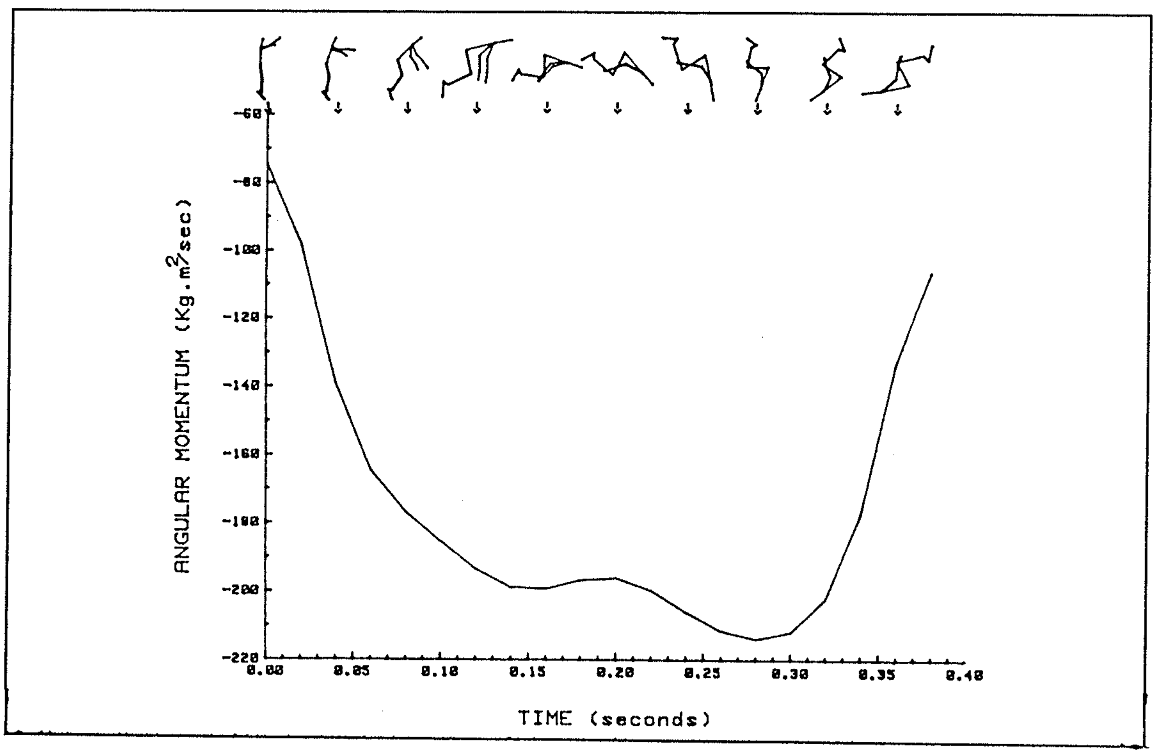

Figure 15: Angular momentum in salto from handspring

SUMMARY AND CONCLUSIONS

Summary

The purpose of this study was to examine the biomechanical factors of the front somersault and the handspring front somersault. Following a review of related literature, a filming of the two movements was undertaken, utilizing seven male subjects and six female subjects. The films were used to derive positional data on the performances. This data was then used to calculate the kinematic and kinetic parameters of the performances.

Based on this study, the execution of the front somersault can be described as having seven stages. The first stage was the run up approach into the somersault. The hurdle was the second stage which was low and quick to keep up the horizontal velocity developed in the run. Contact was the third phase. Here the feet touched the ground with the body inclined backwards. This was a more pronounced position in the handspring. Ground time could be separated into two parts, that of braking time, then force time, whereby the body was first reduced to zero vertical velocity, then the velocity increased as the hips, knees and ankles extended. Take-off was the position when the body became airborne, and the trajectory was set for a parabolic motion of the C of G. Air time was the sixth phase, when the body underwent changes of motion by tucking in order to reduce the moment of inertia and increase the angular velocity. Landing was the final stage where the ankles, knees, and hips flexed in order to absorb the energy of the falling body.

The handspring to front somersault approach varied the phase slightly, since, an initial braking motion with the hands placed on the floor for the handspring was involved. This action resulted in a number of changes in body position between contact, ground time and take-off. The results of these positional changes had an effect on various body motions such as the angular velocities of the upper body parts. Also changed was the ground time and amount of force able to be generated during that time.

Conclusions

Following this study, the conclusions which appear to be justified are:

1. There was a significant difference in the vertical ground reaction forces with the running approach generating about 8.5 times body weight, and the handspring generating a peak of about 6.7 times body weight.
2. There was a difference in the pattern for the horizontal ground forces with a double peak for the

handspring due to the position of the body on leg extension.

3. The angular velocities of the upper body parts was significantly greater for the handspring during ground time than the running approach.
4. The angle of the body on contact was further inclined for a handspring than for a front somersault.
5. The angle of the body at take-off was past the vertical for the somersault, while the handspring take-off was still before vertical.
6. The ground time was significantly shorter for the somersault than for the handspring.
7. The running somersault travelled significantly further than the somersault from the handspring, but there was questionable evidence as to it travelling higher. Since the air times were not significantly different, and only one height measurement showed significance at the .05 level this presented no sure case.
8. The poorer performances had significantly longer ground times indicating a lack of power and fast jumping reflexes.
9. The better performances had a significantly higher resultant force to body weight ratio, since with more force generated, there would result a higher position in the air.

Suggestions for Further Investigation

Based on this study, the following suggestions are offered for future investigations:

1. Further attention in the area of impact forces on force plates with the ability to record readings at a speed of 1000 Hertz, and up to 9000 Newtons. Since impact forces were ranging up to twelve times body weight and ground times of less than one tenth of a second could be expected, the plate would have to be sturdy, and a data read out should try for a large series during this interval in order not to miss the peak forces.
2. Improved data for body segment parameters for smaller bodies such as female gymnasts. There was a problem in finding the angular momentum, and values appeared to be larger than was shown in other related literature.

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Appendix A

MATHEMATICAL EQUATIONS

Appendix A

Mathematical Calculations

1. $H = (Ycofg - Yrtoe) * Cfact$

2. $D = (Xrtoeland - Xrtoetakeoff) * Cfact$

3. $T = (F(\#)end - F(\#)begin) * Time$

4. $\Theta = ATN(Xcofg - Xrtoe)/(Ycofg - Yrtoe)$

5. $V_1 = (X_2 - X_1)/Time$

6. $ax = (V_2 - V_1)/Time$

7. $Fx = m * ax$

8. $Fy = (m * ay) + (m * 9.81)$

9. $a_1 = (v_2 - v_1)/groundtime$

10. $F_1 = m * a_1$

11. $T/2$ = ascent time = descent time

12. $H_1 = 1/2 * g * (T/2)^2$

13. $v_3 = g * (T/2)$

14. $F_2 * t_2 = m * (v_3 - v_0)$

15. $a_2 = (v_3 - v_0)/t_2$

16. $F_2 = m * a_2$

17. $W = (Angle_2 - Angle_1)/groundtime$

18. $C.F. = m * W^2 * r$

19. $M = \sum_{i=1}^{14} (I_i w_i + m_i r_i^2 w_i^* \quad)$

20. $I_1 = m_1 k_1^2$

Variable List:

H = the change in height of the C of G

Ycofg = the Y value for cofg from digitizing

Yrtoe = the Y value for the floor

Cfact = the conversion factor from digitizing program

D = the distance travelled horizontally

Xrtoeland = the X value of right toe on landing from digitizing

Xrtoetakeoff = the X value of right toe at take-off

T = the time interval between events

F(#)end = the last frame of interest

F(#)begin = the first frame to be considered

Time = the time between frames (.01)

Θ = the angle of the body

V_1 = the velocity of the first instant in X-direction

a_1 = the acceleration in X-direction at first instant

Fx = the force in the X-direction

m = the mass of the subject

ax = the acceleration in the X-direction

Fy = the force in the Y-direction

ay = the acceleration in the Y-direction

a_1 = the X-acceleration from Smith (1983)

v_2 = the velocity at take-off in X-direction

v_1 = the velocity at contact in X-direction

groundtime = the time interval of foot contact

F_1 = the X-force as calculated from Smith (1983)

T/2 = one half of the air time during the somersault

H_1 = the predicted height from Smith (1983)

g = the force due to gravity (9.81 m/s^2)

v_3 = the velocity at take-off in Y-direction from Smith (1983)

F_2 = the Y-force from Smith (1983)

t_2 = the force time when the body is moving upwards while in contact with the floor

v_0 = the Y-velocity at lowest C of G (0 m/sec)

a_2 = the Y-acceleration from Smith (1983)

W = the angular velocity of the body

$Angle_2$ = the angle of the body at take-off

$Angle_1$ = the angle of the body at contact

C.F. = the centripetal force during groundtime

r = the average radius of the body from toes to C of G

M = the angular momentum of the body

I_1 = the moment of inertia about the transverse axis of body segment 1

w_1 = the angular velocity of body segment 1

m_1 = the mass of body segment 1

r_1 = the radius from the C of G of the body to the C of G of segment 1

w_1^* = the angular velocity of segment 1 about the C of G of the body

k_1 = the radius of gyration of body segment 1

Appendix B

COMPUTER PROGRAMS UTILIZED

```
10   ! File:  FORCES                 Cartridge: R. SHORE THESIS (1)
20   ! Date:  July 11, 1984          Author: Rick Shore
30   ! For calculating the angle of take-off of a body, and the pivotal
40   ! rotation while in contact with the floor, and finding the centripetal
50   ! force at take-off. Also the average distance of the cofg to the floor
60   ! is calculated to use in formula: CF = m*(angular rotation)^2*r
70   ! This program finds the X and Y forces at take-off and the resultant
80   ! force and direction. Times on the gound, in extension and in air are
90   ! also found. Height and distance travelled are also computed.
100  ! Keys: ANGLE,ANGULAR ROTATION,CENTRIPETAL FORCE,SOMERSAULT,FRONT HANDSPRING,GYMN,SHORE
110  ! ----------------------------------------------------------------------
120  DIM Format$[180],Descf$(90)[100]
130  DIM Xpt(100,21),Ypt(100,21)
140  DIM Cofg(100,2),X(100),Sc(4),Loc(4),Desc$[180]
150  DIM Y(100),R(100),Xvelcofg(40)
160  DIM Xp2(100,21),Yp2(100,21),Cofg2(100,2)
170  DEF FNArctan(X,Y)=ATN(Y/X)+PI*(X<0)+2*PI*((X>0) AND (Y<0))
180  PRINTER IS 16
190  INPUT "Do you want the old, or new version of reading in the data file [O/N]",Version$
200  IF Version$="N" THEN GOSUB Readin
210  IF Version$="O" THEN GOSUB Oldreadin
220  PRINT PAGE;
230  GOSUB Printout
240  INPUT "DO YOU WANT A HARD COPY [Y/N]",H$
250  IF H$="N" THEN GOTO 290
260     PRINTER IS 7,0
270     GOSUB Printout
280     PRINTER IS 16
290  INPUT "Do you want this data stored [Y/N]",Store$
300  IF Store$="Y" THEN GOSUB Store
310  IF (Store$<>"Y") OR (UPC$(P$)="Y") THEN GOTO 330
320     PRINT LIN(2);"DATA STORED IN FILE NAMED: ";File$
330  GOSUB Hpbeep
340 ! GOSUB Plot
350  END
360 ! ----------------------------------------------------------------------
370 Store:INPUT "Enter a name for the data file [maximum of 6 characters]",File$
380      Numrecs=2
390      ON ERROR GOTO Storerror
400      DISP "Please insert the data cartridge -- then press 'CONTINUE'"
410      PAUSE
420      DISP "";File$;" is being created"
430      CREATE File$,Numrecs,180
440      ASSIGN #1 TO File$
450      DISP "Data is being stored in ";File$;""
460      PRINT #1;"Format$,Descf$" !Angle contact,Angle take-off,Angvel,Centfr
470  !   PRINT #1;"Avrad,Angle transition,In x-vel,To x-vel,X-acc,X-force"
480  !   PRINT #1;"Y-vel to,Y-acc,Y-force,Centfr/resforce"
490  !   PRINT #1;"Grtime,Frtime,Airtime"
500  !   PRINT #1;"Resforce,Angle force,Wt subj,Resforce/wt"
```

```
510  !   PRINT #1;"Ht up cg,Ht dn cg,Calc ht,Cng cg @ grnd"
520  !   PRINT #1;"Dist cg,Dist rt toe,Ang TO - Ang force"
530  !   PRINT #1;"Mass,Age,Height"
540      PRINT #1;Descf$
550      PRINT #1;Angle1
560      PRINT #1;Angle2
570      PRINT #1;Angvel
580      PRINT #1;Centfr
590      PRINT #1;Avrr
600      PRINT #1;Angle
610      PRINT #1;Xvel1
620      PRINT #1;Xvel2
630      PRINT #1;Xacc
640      PRINT #1;Xforce
650      PRINT #1;Yvel2
660      PRINT #1;Yacc
670      PRINT #1;Yforce
680      PRINT #1;Centfr/Resforce
690      PRINT #1;Grtime
700      PRINT #1;Frtime
710      PRINT #1;Airtime
720      PRINT #1;Resforce
730      PRINT #1;Forceangle
740      PRINT #1;Weight
750      PRINT #1;Resforce/Weight
760      PRINT #1;Maxhtup
770      PRINT #1;Maxhtdn
780      PRINT #1;Calcht
790      PRINT #1;Grhtcg
800      PRINT #1;Distcg
810      PRINT #1;Distoe
820      PRINT #1;Angle2-Forceangle
830      PRINT #1;Mass
840      PRINT #1;Age
850      PRINT #1;Height
860      ASSIGN # TO #1
870      DISP "Data storage completed"
880      WAIT 1000
890      RETURN
900 ! ------------------------------------------------------------------------
910 Storerror:  !
920      BEEP
930      IF (ERRN<>64) AND (ERRN<>55) THEN GOTO 1030
940          DISP "ERROR -- not enough room on this tape (Please insert another then CONTINUE)"
950          GOTO 410
960      IF ERRN<>80 THEN GOTO 990
970          DISP "ERROR -- cartridge not inserted (properly) (Insert and press CONTINUE)"
980          GOTO 410
990      IF (ERRN<>53) AND (ERRN<>54) THEN GOTO 1020
1000         EDIT "ERROR -- improper or duplicate file name (Enter a new file name)",File$
```

```
1010          GOTO 420
1020      PRINT PAGE;" ERROR -- an error has occurred while trying to store data"
1030      PRINT LIN(1);"   Please do not turn off computer !! Get assistance"
1040      PRINT "          (Error message: ";ERRM$;" )"
1050      ON KBD GOTO 1080 ,ALL
1060      DISP "NOTE; Only the PAUSE key will pause his program (all other keys disabled)"
1070      GOTO 1070
1080      K$=KBD$
1090      K=0
1100      IF LEN(K$)=2 THEN K=NUM(K$[2])
1110      IF K=17 THEN GOTO 1140
1120      BEEP
1130      GOTO 1050
1140      DISP "PROGRAM PAUSED -- press CONTINUE to return to eror trap"
1150      PAUSE
1160      GOTO 1140
1170 ! ---------------------------------------------------------------
1180 Hpbeep:FOR B=1 TO 10
1190           BEEP
1200           WAIT 50
1210        NEXT B
1220        RETURN
1230 ! ----------------------------------------------------------------
1240 Readin:  ! READIN DATA FROM FILE
1250 INPUT "PLEASE ENTER NAME OF FILE",File$
1260 DISP "INSERT THE DATA CARTRIDGE THEN CONTINUE"
1270 PAUSE
1280 ASSIGN #1 TO File$,V
1290 IF V<>0 THEN GOTO Readin
1300 READ #1;Format$,Desc$
1310 PRINT Format$
1320 PRINT Desc$
1330 READ #1;Numfrms,Numpts,Cfact,Time
1340 ! PRINT "FRAME";Numfrms,"POINTS";Numpts
1350 ! PRINT "CFact";Cfact,"TIME";Time;LIN(1)
1360 PRINT "COORDINATES"
1370 PRINT RPT$("-",25)
1380 F=1
1390 L=Numfrms
1400 INPUT "Please enter the mass of the person",Mass
1410 INPUT "Please enter the age of the person",Age
1420 INPUT "Please enter the height of the person",Height
1430 INPUT "Please enter the frame numbers to be read in [F,L]",F,L
1440 INPUT "Please enter the frame numbers of contact and take-off [C,T]",C,T
1450 Fr=F
1460 Sumr=0
1470 I=1
1480 FOR F=Fr TO L
1490     PRINT "Frame:";F
1500     IF (File$="FSJH1A") AND (F=12) THEN GOTO 1710
```

```
1510     READ #1,F+2            ! Starts a new record !!!!
1520     FOR P=1 TO Numpts
1530        READ #1;Xpt(I,P),Ypt(I,P)
1540 !      PRINT Xpt(I,P);Ypt(I,P),
1550     NEXT P
1560     READ #1;Cofg(I,1),Cofg(I,2)
1570     PRINT LIN(1);
1580     PRINT Cofg(I,1);Cofg(I,2)
1590     PRINT LIN(1);RPT$("-",25)
1600     IF (F<C) OR (F>T) THEN GOTO 1710
1610        IF F<>C THEN GOTO 1650
1620            X=Cofg(I,1)-Xpt(I,16)
1630            Y=Cofg(I,2)-Ypt(I,16)
1640            Angle1=FNArctan(X,Y)
1650        IF F<>T THEN GOTO 1690
1660            X=Cofg(I,1)-Xpt(I,16)
1670            Y=Cofg(I,2)-Ypt(I,16)
1680            Angle2=FNArctan(X,Y)
1690        R(I)=((Cofg(I,1)-Xpt(I,16))^2+(Cofg(I,2)-Ypt(I,16))^2)^.5*Cfact
1700        Sumr=Sumr+R(I)
1710     I=I+1
1720 NEXT F
1730 Numfrms=I-1
1740 Grtime=(T-C)*Time
1750 IF File$="FSGT1A" THEN Grtime=Grtime+.02
1760 I=Fr
1770 Sumxvel=0
1780 FOR F=Fr TO C
1790     Xvelcofg(I)=(Cofg(I+1,1)-Cofg(I,1))/Time*Cfact
1800     Sumxvel=Sumxvel+Xvelcofg(I)
1810     PRINTER IS 7,0,WIDTH(132)
1820     PRINT "FRAME","Xvelcofg(I)"
1830     PRINT LIN(1),RPT$("-",40)
1840     PRINT F,Xvelcofg(I)
1850     PRINT LIN(1)
1860     I=I+1
1870 NEXT F
1880 PRINTER IS 16
1890 Xvel1=Sumxvel/(C-Fr+1)
1900 Angle=Angle2-Angle1
1910 Avrr=Sumr/(T-C+1)
1920 Angvel=Angle/Grtime
1930 Centfr=Mass*Angvel^2*Avrr
1940 MAT Xpt=Xpt*(Cfact)
1950 MAT Ypt=Ypt*(Cfact)
1960 MAT Cofg=Cofg*(Cfact)
1970 INPUT "Please enter the name of file for air time",Fil2$
1980 DISP "INSERT THE DATA CARTRIDGE THEN CONTINUE"
1990 PAUSE
2000 ASSIGN #2 TO Fil2$,V
```

```
2010 IF V<>0 THEN GOTO 1970
2020 READ #2;Format$,Desc$
2030 PRINT Format$
2040 PRINT Desc$
2050 READ #2;Numfrms,Numpts,Cfact,Time
2060 PRINT "COORDINATES"
2070 PRINT RPT$("-",25)
2080 F=1
2090 L=Numfrms
2100 INPUT "Please enter the first and last frames to be read in [F,L]",F,L
2110 INPUT "Please enter the frames of take-off and landing [U,D]",U,D
2120 Fr=F
2130 I=1
2140 Maxcg=0
2150 Mincg=99999
2160 FOR F=Fr TO L
2170     PRINT "Frame:";F
2180     IF (Fil2$="HSFSRB") AND ((F=6) OR (F=7)) THEN GOTO 2300
2190     READ #2,F+2              !STARTS A NEW RECORD   !!
2200     FOR P=1 TO Numpts
2210         READ #2;Xp2(I,P),Yp2(I,P)
2220 !       PRINT Xp2(I,P);Yp2(I,P)
2230     NEXT P
2240     READ #2;Cofg2(I,1),Cofg2(I,2)
2250     PRINT LIN(1)
2260     PRINT Cofg2(I,1);Cofg2(I,2)
2270     PRINT LIN(1);RPT$("-",25)
2280     IF Maxcg<Cofg2(I,2) THEN Maxcg=Cofg2(I,2)
2290     IF Mincg>Cofg2(I,2) THEN Mincg=Cofg2(I,2)
2300     I=I+1
2310 NEXT F
2320 Numfrms=I-1
2330 Fr=Fr-1
2340 Distcg=(Cofg2(D-Fr,1)-Cofg2(U-Fr,1))*Cfact
2350 Distoe=(Xp2(D-Fr,16)-Xp2(U-Fr,16))*Cfact
2360 ! Maxht=(Maxcg-Mincg)*Cfact
2370 Maxhtup=(Maxcg-Cofg2(U-Fr,2))*Cfact
2380 Maxhtdn=(Maxcg-Cofg2(D-Fr,2))*Cfact
2390 Airtime=(D-U)*Time
2400 Frtime=(U-(Fr+1))*Time
2410 IF Fil2$="HSFSJH" THEN Frtime=Frtime+.01
2420 IF Fil2$="HSFSMG" THEN Frtime=Frtime-.01
2430 IF Fil2$="HSFSCB" THEN Frtime=Frtime-.02
2440 IF Fil2$="HSFSRB" THEN Frtime=Frtime+.02
2450 IF Fil2$="HSFSAR" THEN Frtime=Frtime+.01
2460 Calcht=.5*9.8*(Airtime/2)^2
2470 Yvel2=9.8*(Airtime/2)
2480 Yacc=Yvel2/Frtime
2490 Yforce=Mass*Yacc
2500 Xvel2=(Cofg2(D-Fr,1)-Cofg2(U-Fr,1))/Airtime*Cfact
```

```
2510 Xacc=(Xvel1-Xvel2)/Grtime
2520 Xforce=Mass*Xacc
2530 Resforce=(Xforce^2+Yforce^2)^.5
2540 Forceangle=FNArctan(Xforce,Yforce)
2550 Weight=Mass*9.8
2560 Grhtcg=(Cofg2(U-Fr,2)-Cofg2(1,2))*Cfact
2570 RETURN
2580 ! ------------------------------------------------------------------
2590 Printout:  ! PRINT OUT OF AVERAGE HEIGHT COFG, ANGLES OF CONTACT
2600            ! AND TAKE-OFF, ANGULAR VELOCITY, AND CENTRIFUGAL FORCE
2610            ! ALSO INCLUDED ARE MAX HT COFG, CALCULATED HT COFG,
2620            ! INITIAL VELOCITY INTO CONTACT, FINAL VELOCITY AT TAKE-OFF
2630            ! ACCELERATIONS IN X AND Y OF COFG, AND X AND Y FORCES, ALSO
2640            ! RESULTANT FORCE, AND DIRECTION OF FORCE
2650 FIXED 3
2660 PRINT File$
2670 PRINT LIN(2)
2680 ! PRINT "FRAME","XptCofG","YptCofG","Xpt TOE"
2690 ! FOR F=1 TO Numfrms
2700 !   PRINT F,Cofg(F,1),Cofg(F,2),Xpt(F,16)
2710 ! NEXT F
2720 ! PRINT LIN(4)
2730 ! PRINT "FRAME","Ypt TOE","Radius"
2740 ! FOR F=1 TO Numfrms
2750 !   PRINT F,Ypt(F,16),R(F)
2760 ! NEXT F
2770 ! PRINT LIN(4)
2780 PRINT "ANGLE AT CONTACT","ANGLE AT TAKE-OFF","ANGULAR VELOCITY","CENTRIPETAL FORCE"
2790 PRINT LIN(1);RPT$("-",80)
2800 PRINT Angle1,Angle2,Angvel,Centfr
2810 PRINT LIN(4)
2820 PRINT "AVERAGE RADIUS","ANGLE OF TRANSITION"
2830 PRINT LIN(1);RPT$("-",80)
2840 PRINT Avrr,Angle
2850 PRINT LIN(4)
2860 PRINT "INITIAL X-VELOCITY","TAKE-OFF X-VELOCITY","X-ACCELERATION","X-FORCE"
2870 PRINT LIN(1),RPT$("-",80)
2880 PRINT Xvel1,Xvel2,Xacc,Xforce
2890 PRINT LIN(4)
2900 PRINT "Y-VELOCITY TAKE-OFF","Y-ACCELERATION","Y-FORCE","CENTFR/RESFORCE"
2910 PRINT LIN(1),RPT$("-",80)
2920 PRINT Yvel2,Yacc,Yforce,Centfr/Resforce
2930 PRINT LIN(4)
2940 PRINT "GROUND TIME","FORCE TIME","AIR TIME"
2950 PRINT LIN(1),RPT$("-",80)
2960 PRINT Grtime,Frtime,Airtime
2970 PRINT LIN(4)
2980 PRINT "RESULTANT FORCE","ANGLE OF FORCE","WEIGHT OF SUBJECT","RES FORCE/WEIGHT"
2990 PRINT LIN(1),RPT$("-",80)
3000 PRINT Resforce,Forceangle,Weight,Resforce/Weight
```

```
3010 PRINT LIN(4)
3020 PRINT "MAX HT UP COFG","MAX HT DN COFG","CALCULATED HEIGHT","CNG COFGHT @ GRND"     !Change of cofg heigh
t while feet are pushing on ground
3030 PRINT LIN(1),RPT$("-",80)
3040 PRINT Maxhtup,Maxhtdn,Calcht,Grhtcg
3050 PRINT LIN(4)
3060 PRINT "DISTANCE COFG","DISTANCE RT TOE","ANG T.O.- ANG FOR"
3070 PRINT LIN(1),RPT$("-",80)
3080 PRINT Distcg,Distoe,Angle2-Forceangle
3090 PRINT LIN(4)
3100 PRINT "Mass","Age","Height"
3110 PRINT LIN(1),RPT$("-",80)
3120 PRINT Mass,Age,Height
3130 PRINT LIN(4)
3140 RETURN
3150 ! ------------------------------------------------------------------------
3160 Plot:       ! PLOT ON PAPER THE POSITIONS OF THE COFG, RIGHT HIP, AND RIGHT TOE
3170    INPUT "DO YOU WANT THE GRAPH PROGRAMS LINKED ON [Y/N]",I$
3180    IF I$<>"Y" THEN GOTO 3230
3190    DISP "INSERT GRAPHICS (1) CARTRIDGE, THEN PRESS CONTINUE"
3200    PAUSE
3210    LINK "Graph",End
3220    LINK "Grftrc",5230
3230    FOR F=1 TO Numfrms
3240        X(F)=(F-1)*Time
3250        Y(F)=Ypt(F,12)                    ! Y POSITION OF RIGHT HIP
3260    NEXT F
3270    CALL Graph(Numfrms,X(*),Y(*),"N",Sc(*),Loc(*))
3280    FOR F=1 TO Numfrms
3290        X(F)=(F-1)*Time
3300        Y(F)=Ypt(F,16)                    ! Y POSITION OF RIGHT TOE
3310    NEXT F
3320    CALL Graph(Numfrms,X(*),Y(*),"Y",Sc(*),Loc(*))
3330    FOR F=1 TO Numfrms
3340        X(F)=(F-1)*Time
3350        Y(F)=Cofg(F,2)                    ! Y POSITION OF COFG
3360    NEXT F
3370    CALL Graph(Numfrms,X(*),Y(*),"Y",Sc(*),Loc(*))
3380    INPUT "DO YOU WANT A GRAPH TRACE [Y/N]",Tr$
3390    IF Tr$="N" THEN GOTO 3410
3400    CALL Graphtrace(Xpt(*),Ypt(*),X(*),Sc(*),Loc(*),Numfrms,Numpts)
3410    RETURN
3420 End:!
```

```
10  ! File:  GRDFR3                 Cartridge: R. SHORE THESIS (1)
20  ! Date:  Nov 9, 1982            Author: Rick Shore
30  ! Desc: Calculation of ground reaction forces in a front handspring,
40  ! for just the frames on the ground (before takeoff).  Note for reading
50  ! a data file that has a format string at the beginning, use the new
60  ! version of the reading subroutine.
70  ! Keys: KINET,DYNAMIC,GROUND REACTION,FORCES,FRONT HANDSPRING,GYMN,SHORE
80  ! -----------------------------------------------------------------------
90  DIM Format$[180],Descf$(90)[100]
100 DIM Xpt(60,21),Ypt(60,21)
110 DIM Cofg(60,2),X(60),Sc(4),Loc(4),Desc$[180]
120 DIM Vel(90,2),Acc(90,2)
130 DIM Grfx(90),Grfy(90)
140 PRINTER IS 16
150 INPUT "Do you want the old, or new version of reading in the data file [O/N]",Version$
160 IF Version$="N" THEN GOSUB Readin
170 IF Version$="O" THEN GOSUB Oldreadin
180 GOSUB Smooth
190 GOSUB Grforce
200 PRINT PAGE;
210 GOSUB Printout
230 INPUT "DO YOU WANT A HARD COPY [Y/N]",H$
240 IF H$="N" THEN GOTO 280
250     PRINTER IS 7,0
260     GOSUB Printout
270     PRINTER IS 16
280 GOSUB Plot
281 END
290 Readin:  ! READIN DATA FROM SPLIT LEAP FILE
300 INPUT "PLEASE ENTER NAME OF FILE",File$
310 DISP "INSERT THE DATA CARTRIDGE THEN CONTINUE"
320 PAUSE
330 ASSIGN #1 TO File$,V
340 IF V<>0 THEN GOTO Readin
350 INPUT "ENTER THE MASS OF THE SUBJECT",Mass
360 READ #1;Format$,Desc$
370 PRINT Format$
380 PRINT Desc$
390 READ #1;Numfrms,Numpts,Cfact,Time
400 INPUT "Please enter the time",Time
410 PRINT "FRAME";Numfrms,"POINTS";Numpts
420 PRINT "CFact";Cfact,"TIME";Time;LIN(1)
430 PRINT "COORDINATES"
440 PRINT RPT$("-",80)
450 F=1
460 L=Numfrms
470 INPUT "Please enter the first and last frames to be read in [F,L]",F,L
480 Fr=F
490 I=1
500 FOR F=Fr TO L
```

```
510       PRINT "Frame:";F
520       READ #1,F+2           ! Starts a new record !!!!
530       FOR P=1 TO Numpts
540           READ #1;Xpt(I,P),Ypt(I,P)
550           PRINT Xpt(I,P);Ypt(I,P),
560       NEXT P
570       READ #1;Cofg(I,1),Cofg(I,2)
580       PRINT LIN(1);
590       PRINT Cofg(I,1);Cofg(I,2)
600       PRINT LIN(1);RPT$("-",80)
610       I=I+1
620   NEXT F
630   Numfrms=I-1
640   MAT Cofg=Cofg*(Cfact)
650   RETURN
660   !    NOT USED
670   FOR F=1 TO Numfrms
680       READ #1;Descf$(F)
690       PRINT F,Descf$(F)
700       IF Descf$(F)="TAKE OFF" THEN Takeoff=F
710   NEXT F
720   RETURN
730 Oldreadin:INPUT "Please enter the name of the data file",File$
740       DISP "Please insert the data cartridge -- then press CONTINUE"
750       PAUSE
760       ASSIGN #1 TO File$,Rerr
770       IF Rerr THEN GOTO Oldreadin
780       READ #1;Desc$,Numfrms,Numpts,Cfact,Time
790       PRINT PAGE;Desc$
800       PRINT "Frames:";Numfrms,"Points:";Numpts
810       INPUT "Please enter the mass of the subject",Mass
820       INPUT "Please enter the time",Time
830       PRINT "Cfact:";Cfact,"Time:";Time;LIN(1);RPT$("-",80)
840       FOR F=1 TO Numfrms
850           READ #1;F,Descf$(F)
860           IF Descf$(F)="TAKE OFF" THEN Takeoff=F
870           PRINT F,Descf$(F)
880           FOR P=1 TO Numpts
890               READ #1;Xpt(F,P),Ypt(F,P)
900               PRINT Xpt(F,P);Ypt(F,P),
910           NEXT P
920           READ #1;Cofg(F,1)
930           READ #1;Cofg(F,2)
940           PRINT LIN(1);Cofg(F,1);Cofg(F,2);LIN(1)
950           IF Takeoff THEN GOTO 970
960       NEXT F
970       MAT Cofg=Cofg*(Cfact)
980       RETURN
990 Smooth:  ! SMOOTHS DATA
1000 ! Numfrms=Takeoff
```

```
1001 INPUT "DO YOU WANT THE FOURIE PROGRAM LINKED ON [Y/N]",F$
1002 IF F$<>"Y" THEN GOTO 1040
1010 DISP "INSERT THE CARTRIDGE HOLDING FILE Fourie, THEN PRESS CONTINUE"
1020 PAUSE
1030 LINK "Fourie",End
1040 BEEP
1050 Ncut=FNFourier_n(Numfrms)
1060 DISP "Please enter a cutoff (Cutoff = approx (";Ncut;"/ 8 ))";
1070 INPUT "",Cutoff
1080 CALL Fourier(Cofg(*),Vel(*),Acc(*),Numfrms,1,Time,Cutoff,1)
1100 CALL Fourier(Cofg(*),Vel(*),Acc(*),Numfrms,2,Time,Cutoff,1)
1110 RETURN
1120 Grforce:   ! CALCULATION OF GROUND REACTION FORCES
1130 FOR F=1 TO Numfrms
1140 !   IF F>Takeoff THEN GOTO Next
1150          Grfx(F)=Mass*Acc(F,1)
1160          Grfy(F)=Mass*Acc(F,2)+Mass*9.81
1170 Next:   NEXT F
1180 RETURN
1190 Printout:  ! PRINT OUT OF GROUND REACTION FORCES
1200 PRINT File$
1210 PRINT LIN(2)
1220 PRINT "FRAME","X-FORCE","Y-FORCE"
1230 FOR F=1 TO Numfrms
1240     PRINT F,Grfx(F),Grfy(F)
1250 NEXT F
1260 RETURN
1270 Plot:    ! PLOT ON PAPER THE FORCES
1271 INPUT "DO YOU WANT THE GRAPH PROGRAMS LINKED ON [Y/N]",I$
1272 IF I$<>"Y" THEN GOTO 1320
1280 DISP "INSERT GRAPHICS (1) CARTRIDGE, THEN PRESS CONTINUE"
1290 PAUSE
1300 LINK "Graph",3810
1310 LINK "Grftrc",7820
1320 FOR F=1 TO Numfrms
1330     X(F)=(F-1)*Time
1340 NEXT F
1350 CALL Graph(Numfrms,X(*),Grfx(*),"N",Sc(*),Loc(*))
1360 INPUT "DO YOU WANT A GRAPH TRACE [Y/N]",Tr$
1370 IF Tr$="N" THEN GOTO 1390
1380 CALL Graphtrace(Xpt(*),Ypt(*),X(*),Sc(*),Loc(*),Numfrms,Numpts)
1390 CALL Graph(Numfrms,X(*),Grfy(*),"N",Sc(*),Loc(*))
1400 INPUT "DO YOU WANT A GRAPH TRACE [Y/N]",Tr$
1410 IF Tr$="N" THEN GOTO 1430
1420 CALL Graphtrace(Xpt(*),Ypt(*),X(*),Sc(*),Loc(*),Numfrms,Numpts)
1430 RETURN
1440 End:!
```

```
10    ! File: ANGMOM                   Cartridge: R. SHORE THESIS (1)
20    ! Date: Sept, 1983                Author: R. Shore
30    ! Desc: This program is designed to calculate the angular momentum
40    ! of the entire body. The data is to be accessed from a random file
50    ! plotted from XYCG4, which has a format string at the beginning.
60    ! Keys: ANGULAR MOMENTUM, MOMENTUM, INERTIA
70    ! ------------------------------------------------------------------
80    DIM Format$[180],Descf$(90)[100]
90    DIM Xpt(20,21),Ypt(20,21),Xcg(20,1),Ycg(20,1),Xseg(20,14),Yseg(20,14)
100   DIM Xvel(20,21),Yvel(20,21),Xcgvel(20,1),Ycgvel(20,1)
110   DIM Xacc(20,21),Yacc(20,21),Xcgacc(20,1),Ycgacc(20,1)
120   DIM Inc(20,14),Incvel(20,14),Incacc(20,14)
130   DIM Cginc(20,14),Cgincvel(20,14),Cgincacc(20,14)
140   SHORT Segperc(1:14),Radgyr(1:14),Segmass(1:14),Inertia(1:14)
150   INTEGER Segpt(1:14,1:2)
160   DIM Segdist(20,14),Angmom(20,1)
170   DIM Time(20,1),Leg$(1),Foot$[160],Var(1),X(20)
180   DIM Sc(4),Loc(4),Desc$[180]
181   INTEGER F(20)
190   RESTORE Order
200   READ Segpt(*)
210   GOSUB Readin
220   GOSUB Smooth
230   GOSUB Segcg
240   GOSUB Segangle
250   GOSUB Inertia
260   GOSUB Cgdist
270   GOSUB Angmom
280   GOSUB Printout
290   GOSUB Plot
300   DISP "Program ANGMOM ended."
310   END
320   ! ---------------------------------------------------------------------
330 Order:DATA 2,1,3,2,4,3,5,6,7,8,8,9,9,10,11,5,12,13,13,14,15,16,17,18,18,19,20,21
340 Readin:   ! Read in the frames that you wish to work with so arrays can be DIMensioned
350        INPUT "Please enter the name of the data file",File$
360        DISP " Please insert the data cartridge -- then press 'CONTINUE'"
370        PAUSE
380        ASSIGN #1 TO File$,Readerror
390        IF NOT Readerror THEN GOTO 460
400            BEEP
410            IF Readerror=1 THEN DISP " ERROR  -- No such file found on this data cartridge"
420            IF Readerror=2 THEN DISP " ERROR  -- File is protected or wrong protect code"
430            CAT
440            WAIT 3000
450            GOTO 350
460        DISP "Loading ";CHR$(131);File$;CHR$(128);
470        OFF ERROR
480        INPUT "ENTER THE MASS OF THE SUBJECT",Mass
490        INPUT "ENTER THE SEX OF THE SUBJECT [M/F]",S$
```

```
500       READ #1;Format$,Desc$
510       PRINT Format$
520       PRINT Desc$
530       READ #1;Numfrms,Numpts,Cfact,Time
540       INPUT "Please enter the time",Time
550       PRINT "FRAME";Numfrms,"POINTS";Numpts
560       PRINT "CFACT";Cfact,"TIME";Time;LIN(1)
570       PRINT "COORDINATES"
580       PRINT RPT$("-",80)
590       F=1
600       L=Numfms
610       INPUT "Please enter the first and last frames to be read in [F/L]",F,L
620       Fr=F
630       I=1
640       FOR F=Fr TO L
650           PRINT "Frame:";F
660           READ #1,F+2           ! Starts a new record !!!!
670           FOR P=1 TO Numpts
680               READ #1;Xpt(I,P),Ypt(I,P)
690               PRINT Xpt(I,P);Ypt(I,P),
700           NEXT P
710           READ #1;Xcg(I,1),Ycg(I,1)
720           PRINT LIN(1);
730           PRINT Xcg(I,1);Ycg(I,1)
740           PRINT LIN(1);RPT$("-",80)
750           I=I+1
760       NEXT F
770       Numfrms=I-1
780       MAT Xpt=Xpt*(Cfact)
790       MAT Ypt=Ypt*(Cfact)
800       MAT Xcg=Xcg*(Cfact)
810       MAT Ycg=Ycg*(Cfact)
820       RETURN
830 Smooth:Link$="Fourie"
840       GOSUB Linksub
850       Ncut=FNFourier_n(Numfrms)
860       DISP "Please enter a cutoff (Cutoff = approx (";Ncut;"/8))";
870       INPUT "",Cutoff
880       INPUT "Do you want to check the smoothed data [Y/N]",Check$
890       Check=0
900       IF Check$="Y" THEN Check=1
910       FOR P=1 TO Numpts
920           DISP "Point";P
930           CALL Fourier(Xpt(*),Xvel(*),Xacc(*),Numfrms,P,Time,Cutoff,Check)
940           CALL Fourier(Ypt(*),Yvel(*),Yacc(*),Numfrms,P,Time,Cutoff,Check)
950       NEXT P
960       CALL Fourier(Xcg(*),Xcgvel(*),Xcgacc(*),Numfrms,1,Time,Cutoff,Check)
970       CALL Fourier(Ycg(*),Ycgvel(*),Ycgacc(*),Numfrms,1,Time,Cutoff,Check)
980       RETURN
990 Segangle:!
```

```
1000      Link$="Ptincl"
1010      GOSUB Linksub
1020      DISP "LOCAL SEGMENT ANGLES AND ANGULAR VELOCITIES"
1030      FOR S=1 TO 14
1040          Prox=Segpt(S,1)
1050          Distal=Segpt(S,2)
1060          Rev=Previnc=0
1070          FOR F=1 TO Numfrms
1080              CALL Ptincl(Xpt(F,Prox),Ypt(F,Prox),Xpt(F,Distal),Ypt(F,Distal),Inc(*),F,S,Rev,Previnc)
1090          NEXT F
1100          Rev=Previnc=0
1110          FOR F=1 TO Numfrms
1120              CALL Ptincl(Xcg(F,1),Ycg(F,1),Xseg(F,S),Yseg(F,S),Cginc(*),F,S,Rev,Previnc)
1130          NEXT F
1140      NEXT S
1150      Link$="Velaci"
1160      GOSUB Linksub
1170      FOR S=1 TO 14
1180          CALL Velacc(Inc(*),Incvel(*),Incacc(*),Numfrms,S,Time)
1190          CALL Velacc(Cginc(*),Cgincvel(*),Cgincacc(*),Numfrms,S,Time)
1200      NEXT S
1210      RETURN
1220 Segcg:!    SEGCOFG CALCULATES THE SEGMENTAL C OF G'S
1230      FOR F=1 TO Numfrms
1240          IF S$="M" THEN RESTORE Male
1250          IF S$="F" THEN RESTORE Female
1260          FOR S=1 TO 14
1270              READ Fact
1280              Prox=Segpt(S,1)
1290              Distal=Segpt(S,2)
1300              Xseg(F,S)=Fact*(Xpt(F,Distal)-Xpt(F,Prox))+Xpt(F,Prox)
1310              Yseg(F,S)=Fact*(Ypt(F,Distal)-Ypt(F,Prox))+Ypt(F,Prox)
1320          NEXT S
1330      NEXT F
1340      RETURN
1350 Male:DATA .468,.43,.436,.55,.436,.43,.468,.63,.433,.434,.5,.433,.434,.5
1360 Female:DATA .468,.434,.458,.55,.458,.434,.468,.569,.428,.419,.5,.428,.419,.5
1370 Inertia:! CALCULATE SEGMENT INERTIAS
1380      IF S$="M" THEN RESTORE Malesegperc
1390      IF S$="F" THEN RESTORE Femalesegperc
1400      READ Segperc(*)
1410      IF S$="M" THEN RESTORE Maleradgyr
1420      IF S$="F" THEN RESTORE Femaleradgyr
1430      READ Radgyr(*)
1440      FOR S=1 TO 14
1450          Segmass(S)=Segperc(S)*Mass
1460          Inertia(S)=Segmass(S)*Radgyr(S)^2
1470      NEXT S
1480      RETURN
1490 ! ALL THESE PERCENTS ARE FROM PLAGENHOEF,1983
```

```
1500 Malesegperc:DATA 0.0065,0.0187,0.0325,0.0826,0.0325,0.0187,0.0065,0.469,.105,.0475,.0143,.105,.0475,.0143
1510 Femalesegperc:DATA .005,.0157,.029,.082,.029,.0157,.005,.45,.1175,.0535,.0133,.1175,.0535,.0133
1520 Maleradgyr:DATA .549,.526,.542,.61,.542,.526,.549,.81,.540,.529,.69,.54,.529,.69
1530 Femaleradgyr:DATA .549,.53,.564,.61,.564,.53,.549,.75,.535,.514,.69,.535,.514,.69      !ALL THESE PERCENT
S ARE FROM PLAGENHOEF,1983
1540 Cgdist:! CALCULATE THE SEGMENTAL DISTANCE FROM THE TOTAL BODY C OF G
1550      FOR F=1 TO Numfrms
1560          FOR S=1 TO 14
1570              Segdist(F,S)=(Xcg(F,1)-Xseg(F,S))^2+(Ycg(F,1)-Yseg(F,S))^2
1580              ! Note: This is distance squared which is what we want!!!
1590          NEXT S
1600      NEXT F
1610      RETURN
1620 Angmom:! CALCULATE THE ANGULAR MOMENTUM !!
1630      FOR F=1 TO Numfrms
1640          Amsum=0
1650          FOR S=1 TO 14
1660              Amsum=Amsum+Inertia(S)*Incvel(F,S)+Segmass(S)*Segdist(F,S)*Cgincvel(F,S)
1670          NEXT S
1680          Angmom(F,1)=Amsum
1690      NEXT F
1700      RETURN
1710 Printout:! PRINT OUT THE DATA
1720      PRINTER IS 7,0,WIDTH(132)
1730      PRINT "ANGULAR MOMENTUM ANALYSIS"
1740      PRINT "*************************";LIN(2)
1750      PRINT "File Data:"
1760      PRINT "----------";LIN(2)
1770      PRINT "File name: ";File$;LIN(1)
1780      PRINT "Description: ";Descr$;LIN(1)
1790      PRINT "Time:";Time;LIN(2)
1800      PRINT "Segment Data:"
1810      PRINT "-------------";LIN(2)
1820      PRINT "Segment","Inertia","Mass"
1830      FOR S=1 TO 14
1840          PRINT S,Inertia(S),Segmass(S)
1850      NEXT S
1860      PRINT LIN(2);"Intermediate Data:"
1870      PRINT "------------------:";LIN(2)
1880      FOR S=1 TO 14
1890          PRINT "Segment:";S;LIN(2)
1900          PRINT "Frame","Local Incline,Angvel",,"Transfer Incline,Angvel"
1910          FOR F=1 TO Numfrms
1920              PRINT F-1+Fr,Inc(F,S);Incvel(F,S),Cginc(F,S);Cgincvel(F,S)
1930          NEXT F
1940          PRINT LIN(2)
1950      NEXT S
1960      PRINT "ANGULAR MOMENTUM"
1970      PRINT "****************";LIN(2)
1980      PRINT "Frame","Angular Momentum"
```

```
1990      FOR F=1 TO Numfrms
2000          PRINT F-1+Fr,Angmom(F,1)
2010      NEXT F
2020      PRINTER IS 16
2030      RETURN
2040 Plot:    ! PLOT ON PAPER THE ANGULAR MOMENTUMS
2050     FOR F=1 TO Numfrms
2060         Time(F,1)=(F-1)*Time
2070         X(F)=Time(F,1)
2080     NEXT F
2090     Var(1)=1
2100     Leg$(1)=""
2110     DISP "INSERT GRAPHICS(1) CARTRIDGE, THEN PRESS CONTINUE"
2120     PAUSE
2130     LINK "Autgrf",End
2150     LINPUT "Please enter a title for the ANGULAR MOMENTUM graph",Foot$
2160     CALL Autograph(Numfrms,1,Time(*),Angmom(*),Var(*),Sc(*),Loc(*),"TIME (seconds)","ANGULAR MOMENTUM (Kg
.m/sec)",Leg$(*),"",Foot$,0)
2170     INPUT "DO YOU WANT A GRAPH TRACE [Y/N]",Tr$
2180     IF T$="N" THEN GOTO 2200
2181        Manual=0
2182        INPUT "Please enter the number of frames to be graphed [Nf]",Nf
2183        REDIM F(1:Nf)
2184        INPUT "Please enter the frames to be graphed [F(*)]",F(*)
2190     CALL Graphtrace(Xpt(*),Ypt(*),X(*),Sc(*),Loc(*),Numfrms,Numpts,Nf,Manual,F(*))
2200     RETURN
2210 Linksub:ON ERROR GOTO Notfound
2220     ASSIGN #1 TO Link$,Rerr
2230     IF Rerr THEN GOTO Notfound
2240     DISP "Linking file ";Link$
2250     LINK Link$,End
2260     OFF ERROR
2270     RETURN
2280 Notfound:BEEP
2290     DISP "Please insert the cartridge holding file ";Link$
2300     GOTO Linksub
2310  ! ----------------------------------------------------------------------
2320 End:!
```

```
10   ! File:  PAIRTS                  Cartridge: R. SHORE THESIS (1)
20   ! Date:  July 24, 1984           Author: Rick Shore
30   ! For calculating the means and standard deviations for a series of
40   ! various measures which are read in from files.
50   ! A paired  t-test for dependent groups
60   ! to compare two different groups (Somi vs Hdspg to somi) and a correlation
70   ! is performed to compare all elements with the judged value of the move.
80   ! Keys: STATISTICS,T-TEST,R-CORRELATION,MEAN,STANDARD DEVIATION,SHORE
90   ! -----------------------------------------------------------------------
100  DIM Angle1(26,2),Angle2(26,2),Angvel(26,2),Centfr(26,2)
110  DIM Avrr(26,2),Angle(26,2),Xvel1(26,2),Xvel2(26,2),Xacc(26,2)
120  DIM Xforce(26,2),Yvel2(26,2),Yacc(26,2),Yforce(26,2),Centfrresforce(26,2)
130  DIM Grtime(26,2),Frtime(26,2),Airtime(26,2),Resforce(26,2)
140  DIM Forceangle(26,2),Weight(26,2),Resforceweight(26,2)
150  DIM Maxhtup(26,2),Maxhtdn(26,2),Calcht(26,2),Grhtcg(26,2)
160  DIM Distcg(26,2),Distoe(26,2),Angle2frcang(26,2)
170  DIM Mass(26,2),Height(26,2),Age(26,2)
180  DIM Format$[180],Descf$(90)[100]
190  DEF FNArctan(X,Y)=ATN(Y/X)+PI*(X<0)+2*PI*((X>0) AND (Y<0))
200  PRINTER IS 16
210  GOSUB Readin
220  PRINT PAGE;
230  GOSUB Calculations
240  END
250 ! -----------------------------------------------------------------------
260 Readin:   ! READIN DATA FROM FILE
270  INPUT "PLEASE ENTER THE NUMBER OF SOMI FILES TO BE READ IN",N1
280  INPUT "PLEASE ENTER THE NUMBER OF HDSPG SOMI FILES TO BE READ IN",N2
290  N3=N1+N2
300  FOR F=1 TO N3
310      DISP "NOTE THAT THE FILES HAVE TO BE SOMI 1ST, HANDSPRING 2ND"
320      WAIT 1000
330      INPUT "PLEASE ENTER NAME OF FILE",File$
340      INPUT "Please enter the somi being performed (run or handspring) [R/H]",Somi$
350      IF Somi$="R" THEN I=1
360      IF Somi$="H" THEN I=2
370      IF (Somi$<>"R") AND (Somi$<>"H") THEN GOTO 340
380      DISP "INSERT THE DATA CARTRIDGE THEN CONTINUE"
390      PAUSE
400      ASSIGN #1 TO File$,V
410      IF V<>0 THEN GOTO Readin
420      READ #1;Format$,Descf$
430      PRINT Format$
440      PRINT Descf$
450      READ #1;Angle1(F,I),Angle2(F,I),Angvel(F,I),Centfr(F,I)
460      READ #1;Avrr(F,I),Angle(F,I)
470      READ #1;Xvel1(F,I),Xvel2(F,I),Xacc(F,I),Xforce(F,I)
480      READ #1;Yvel2(F,I),Yacc(F,I),Yforce(F,I),Centfrresforce(F,I)
490      READ #1;Grtime(F,I),Frtime(F,I),Airtime(F,I)
500      READ #1;Resforce(F,I),Forceangle(F,I),Weight(F,I),Resforceweight(F,I)
```

```
510      READ #1;Maxhtup(F,I),Maxhtdn(F,I),Calcht(F,I),Grhtcg(F,I)
520      READ #1;Distcg(F,I),Distoe(F,I),Angle2frcang(F,I)
530      READ #1;Mass(F,I),Age(F,I),Height(F,I)
540      PRINT RPT$("-",25)
550      PRINT LIN(1);
560  NEXT F
570  RETURN
580 ! ----------------------------------------------------------------
590 Calculations: ! Calculates the mean and standard deviation for each set
600  CALL Stat(N1,N2,Angle1(*),"Angle1")
610  CALL Stat(N1,N2,Angle2(*),"Angle2")
620  CALL Stat(N1,N2,Angvel(*),"Angvel")
630  CALL Stat(N1,N2,Centfr(*),"Centfr")
640  CALL Stat(N1,N2,Avrr(*),"Avrr")
650  CALL Stat(N1,N2,Angle(*),"Angle")
660  CALL Stat(N1,N2,Xvel1(*),"Xvel1")
670  CALL Stat(N1,N2,Xvel2(*),"Xvel2")
680  CALL Stat(N1,N2,Xacc(*),"Xacc")
690  CALL Stat(N1,N2,Xforce(*),"Xforce")
700  CALL Stat(N1,N2,Yvel2(*),"Yvel2")
710  CALL Stat(N1,N2,Yacc(*),"Yacc")
720  CALL Stat(N1,N2,Yforce(*),"Yforce")
730  CALL Stat(N1,N2,Centfrresforce(*),"Centfrresforce")
740  CALL Stat(N1,N2,Grtime(*),"Grtime")
750  CALL Stat(N1,N2,Frtime(*),"Frtime")
760  CALL Stat(N1,N2,Airtime(*),"Airtime")
770  CALL Stat(N1,N2,Resforce(*),"Resforce")
780  CALL Stat(N1,N2,Forceangle(*),"Forceangle")
790  CALL Stat(N1,N2,Resforceweight(*),"Resforceweight")
800  CALL Stat(N1,N2,Maxhtup(*),"Maxhtup")
810  CALL Stat(N1,N2,Maxhtdn(*),"Maxhtdn")
820  CALL Stat(N1,N2,Calcht(*),"Calcht")
830  CALL Stat(N1,N2,Grhtcg(*),"Grhtcg")
840  CALL Stat(N1,N2,Distcg(*),"Distcg")
850  CALL Stat(N1,N2,Distoe(*),"Distoe")
860  CALL Stat(N1,N2,Angle2frcang(*),"Angle2frcang")
870  RETURN
880 End: !
890  ! -------------------------------------------------------------
900  SUB Stat(N1,N2,A(*),Name$)
910      DIM Dif(26),Dev(26)
920      DIM A2(30)
930      GOSUB Statistics
940      GOSUB Printout
950      END
960 Statistics:   ! Calculations of means, standard deviations and t-test
970      N3=N1+N2
980      Sumdif=0
990      Sumdev=0
1000     Stdev=0
```

```
1010     FOR I=1 TO N3-1
1020         Dif(I)=A(I,1)-A(I+1,2)   !USED FOR PAIRED T-TEST OF CORRELATED MEANS
1030         Sumdif=Sumdif+Dif(I)
1040         I=I+1
1050     NEXT I
1060     Meandif=Sumdif/N1
1070     FOR I=1 TO N3
1080         IF Dif(I)=0 THEN GOTO 1110
1090             Dev(I)=(Meandif-Dif(I))^2
1100             Sumdev=Sumdev+Dev(I)
1110     NEXT I
1120     Stdev=(Sumdev/(N1-1))^.5
1130     Sterror=Stdev/N1^.5
1140     Tsc=Meandif/Sterror
1150 Printout:   ! PRINT OUT OF ALL STATISTICAL FACTORS
1160 !   INPUT "DO YOU WANT A HARD COPY [Y/N]",H$
1170 !   IF H$="N" THEN GOTO 1300
1180         PRINTER IS 7,0
1190         FIXED 3
1200     PRINT LIN(2)
1210     PRINT Name$
1220     PRINT LIN(1);RPT$("-",25)
1230     PRINT LIN(3)
1240     PRINT "MEAN DIFFERENCE","SQ DEV ALL"
1250     PRINT LIN(1);RPT$("-",80)
1260     PRINT Meandif,Sumdev
1270     PRINT LIN(3)
1280     PRINT "ST DEV DIFFERENCES","ST ERROR MEAN DIF"
1290     PRINT LIN(1);RPT$("-",80)
1300     PRINT Stdev,Sterror
1310     PRINT LIN(3)
1320     PRINT "PAIRED T-TEST BETWEEN GROUPS"
1330     PRINT LIN(1);RPT$("-",80)
1340     PRINT Tsc
1350     PRINT LIN(1);RPT$("-",80)
1360     PRINT LIN(1);RPT$("-",80)
1370     PRINT LIN(6)
1380     PRINTER IS 16
1390 SUBEND
```

```
10   ! File:  NSTATS                  Cartridge: R. SHORE DATA(3)
20   ! Date:  August 10, 1984         Author: Rick Shore
30   ! For calculating the means and standard deviations for a series of
40   ! various measures which are read in by hand. A t-test is performed
50   ! to compare two different groups (Somi vs Hdspg to somi) and a correlation
60   ! is performed to compare all elements with the judged value of the move.
70   ! Keys: STATISTICS,T-TEST,R-CORRELATION,MEAN,STANDARD DEVIATION,SHORE
80   ! ----------------------------------------------------------------------
90   DIM Headinc(26,2),Trunkinc(26,2),Armvel(26,2),Arminc(26,2)
100  DIM Headvel(26,2),Trunkvel(26,2),Score(26,2)
110  DIM Yforce(26,2),Smforc(26,2)
120  DIM Format$[180],Descf$(90)[10],Dmove$(26)[2],Dsex$(26)[2],Dper$(26)[2]
130  PRINTER IS 16
140  GOSUB Readin
150  PRINT PAGE;
160  GOSUB Calculations
170  GOSUB Store
180  END
190 ! -----------------------------------------------------------------------
200 Store:    ! STORE DATA THAT HAS BEEN FED IN
210       INPUT "Enter a name for the data file [maximum 6 characters]",File$
220       Numrecs=10
230       DISP "Please insert the data cartridge -- then press 'CONTINUE'"
240       PAUSE
250       DISP "";File$;" IS BEING CREATED"
260       CREATE File$,Numrecs,180
270       ASSIGN #1 TO File$
280       DISP "Data is being stored in ";File$;""
290       FOR F=1 TO N3
291           I=1
300           PRINT #1;Descf$(F)
310           PRINT #1;Dmove$(F)
320           PRINT #1;Dsex$(F)
330           PRINT #1;Dper$(F)
331           IF Arminc(F,I)=0 THEN I=2
340           PRINT #1;Arminc(F,I),Headinc(F,I),Trunkinc(F,I)
350           PRINT #1;Armvel(F,I),Headvel(F,I),Trunkvel(F,I)
360           PRINT #1;Score(F,I),Yforce(F,I),Smforc(F,I)
370       NEXT F
380       ASSIGN * TO #1
390       DISP "Data storage completed"
400       WAIT 1000
410       RETURN
420  ! -------------------------------------------------------------------
430 Readin:   ! READIN DATA FROM FILE
440  INPUT "PLEASE ENTER THE NUMBER OF SOMI FILES TO BE READ IN",N1
450  INPUT "PLEASE ENTER THE NUMBER OF HDSPG SOMI FILES TO BE READ IN",N2
460  N3=N1+N2
470  PRINTER IS 7,0,WIDTH(132)
471  FIXED 3
```

```
480 PRINT "Arminc","Headinc","Trunkinc","Armvel","Headvel","Trunkvel"
490 PRINT LIN(3)
500 PRINT LIN(1);RPT$("-",130)
510 PRINTER IS 16
610 FOR F=1 TO N3
620     INPUT "PLEASE ENTER NAME OF FILE",File$
630     Descf$(F)=File$
640     INPUT "Please enter the somi being performed (run or handspring) [R/H]",Somi$
650     IF (Somi$<>"R") AND (Somi$<>"H") THEN GOTO 640
660     Dmove$(F)=Somi$
661     INPUT "Is comparison between move type (run vs handspring)[Y/N]",Ty$
662     IF (Ty$<>"Y") AND (Ty$<>"N") THEN GOTO 661
663     IF Ty$="N" THEN GOTO 670
665         IF Somi$="R" THEN I=1
666         IF Somi$="H" THEN I=2
670     INPUT "Please enter the sex of the subject [M/F]",Sex$
680     IF (Sex$<>"M") AND (Sex$<>"F") THEN GOTO 670
690     Dsex$(F)=Sex$
691     INPUT "Is comparison between sexes [Y/N]",S$
692     IF (S$<>"Y") AND (S$<>"N") THEN GOTO 691
694     IF S$="N" THEN GOTO 710
695         IF Sex$="M" THEN I=1
696         IF Sex$="F" THEN I=2
710     INPUT "Please enter the type of performance GOOD or BAD [G/B]",Per$
720     Dper$(F)=Per$
721     INPUT "Is comparison between performance (good to bad) [Y/N]",P$
722     IF (P$<>"Y") AND (P$<>"N") THEN GOTO 721
723     IF P$="N" THEN GOTO 780
724         IF Per$="G" THEN I=1
726         IF Per$="B" THEN I=2
780     A=0
790     INPUT "ENTER THE ARMINC,HEADINC,TRUNKINC",A,H,T
800     IF A=0 THEN GOTO 790
810     Arminc(F,I)=A
820     Headinc(F,I)=H
830     Trunkinc(F,I)=T
840     X=0
850     INPUT "ENTER THE ARMVEL,HEADVEL,TRUNKVEL",X,Y,Z
860     IF X=0 THEN GOTO 850
870     Armvel(F,I)=X
880     Headvel(F,I)=Y
890     Trunkvel(F,I)=Z
891     T=0
900     INPUT "Enter the SCORE, GRAPHED Y FORCE,SMITH'S Y-FORCE",T,U,V
910     IF T=0 THEN GOTO 900
920     Score(F,I)=T
930     Yforce(F,I)=U
940     Smforc(F,I)=V
950     PRINTER IS 7,0,WIDTH(132)
960     PRINT File$
```

```
970     PRINT LIN(1)
980     PRINT Arminc(F,I),Headinc(F,I),Trunkinc(F,I),Armvel(F,I),Headvel(F,I),Trunkvel(F,I)
990     PRINT LIN(1);RPT$("-",130)
1000    PRINT "SCORE","GRAPH Y-FORCE","SMITH Y-FORCE"
1010    PRINT LIN(1)
1020    PRINT Score(F,I),Yforce(F,I),Smforc(F,I)
1030    PRINT LIN(1);RPT$("-",130)
1040    PRINT LIN(3)
1050    PRINTER IS 16
1060 NEXT F
1070 RETURN
1080 ! --------------------------------------------------------------------
1090 Calculations:! Calculates the mean and standard deviation for each set
1100 INPUT "DO YOU WANT AN INDEPENDENT OR PAIRED T-TEST PERFORMED?[I/P]",Test$
1110 IF (Test$<>"I") AND (Test$<>"P") THEN GOTO 1100
1120 ! IF Test$="P" THEN GOTO 1230     ! Note if paired, program does both so
1130                                   ! mean and standard deviation can be found
1140    CALL Stat(N1,N2,Arminc(*),"Arminc")
1150    CALL Stat(N1,N2,Headinc(*),"Headinc")
1160    CALL Stat(N1,N2,Trunkinc(*),"Trunkinc")
1170    CALL Stat(N1,N2,Armvel(*),"Armvel")
1180    CALL Stat(N1,N2,Headvel(*),"Headvel")
1190    CALL Stat(N1,N2,Trunkvel(*),"Trunkvel")
1200    CALL Stat(N1,N2,Score(*),"Score")
1210    CALL Stat(N1,N2,Yforce(*),"Yforce")
1220    CALL Stat(N1,N2,Smforc(*),"Smforc")
1230 IF Test$="I" THEN GOTO 1330
1240    CALL Statpr(N1,N2,Arminc(*),"Arminc")
1250    CALL Statpr(N1,N2,Headinc(*),"Headinc")
1260    CALL Statpr(N1,N2,Trunkinc(*),"Trunkinc")
1270    CALL Statpr(N1,N2,Armvel(*),"Armvel")
1280    CALL Statpr(N1,N2,Headvel(*),"Headvel")
1290    CALL Statpr(N1,N2,Trunkvel(*),"Trunkvel")
1300    CALL Statpr(N1,N2,Score(*),"Score")
1310    CALL Statpr(N1,N2,Yforce(*),"Yforce")
1320    CALL Statpr(N1,N2,Smforc(*),"Smforc")
1330 RETURN
1340 End: !
1350 ! ----------------------------------------------------------------
1360 SUB Stat(N1,N2,A(*),Name$)
1370    DIM A2(30)
1380    GOSUB Statistics
1390    GOSUB Printout
1400    END
1410 Statistics:  ! Calculations of means, standard deviations and t-test
1420    S1=0
1430    Sq1=0
1440    S2=0
1450    Sq2=0
1460    S3=0
```

```
1470     Sq3=0
1480     Ts1=0
1490     Ts2=0
1500     N3=N1+N2
1510     FOR I=1 TO N3
1520         S1=S1+A(I,1)
1530         Sq1=Sq1+A(I,1)^2
1540         S2=S2+A(I,2)
1550         Sq2=Sq2+A(I,2)^2
1560     NEXT I
1570     S3=S1+S2
1580     Sq3=Sq1+Sq2
1590     Mean1=S1/N1
1600     Mean2=S2/N2
1610     Mean3=S3/N3
1620     Sd1=((Sq1-S1^2/N1)/(N1-1))^.5
1630     Sd2=((Sq2-S2^2/N2)/(N2-1))^.5
1640     Sd3=((Sq3-S3^2/N3)/(N3-1))^.5
1650     FOR I=1 TO N3
1660         IF A(I,1)=0 THEN GOTO 1680
1670             Ts1=Ts1+(A(I,1)-Mean1)^2         !T-Test statistics
1680         IF A(I,2)=0 THEN GOTO 1700
1690             Ts2=Ts2+(A(I,2)-Mean2)^2
1700     NEXT I
1710     St=((Ts1+Ts2)/(N1-1+(N2-1)))^.5
1720     Std=St*((N1+N2)/(N1*N2))^.5
1730     Ttest=(Mean1-Mean2)/Std
1740 Printout:   ! PRINT OUT OF ALL STATISTICAL FACTORS
1750 !   INPUT "DO YOU WANT A HARD COPY [Y/N]",H$
1760 !   IF H$="N" THEN GOTO 1300
1770         PRINTER IS 7,0
1780         FIXED 3
1790     PRINT LIN(2)
1800     PRINT Name$
1810     PRINT LIN(1);RPT$("-",25)
1820     PRINT LIN(3)
1830     PRINT "SUM SOMI","SUM HNDSPG","SUM ALL"
1840     PRINT LIN(1);RPT$("-",80)
1850     PRINT S1,S2,S3
1860     PRINT LIN(3)
1870     PRINT "SUM SQ SOMI","SUM SQ HNDSPG","SUM SQ ALL"
1880     PRINT LIN(1);RPT$("-",80)
1890     PRINT Sq1,Sq2,Sq3
1900     PRINT LIN(3)
1910     PRINT "MEAN SOMI","MEAN HNDSPG","MEAN ALL"
1920     PRINT LIN(1);RPT$("-",80)
1930     PRINT Mean1,Mean2,Mean3
1940     PRINT LIN(3)
1950     PRINT "S.D. SOMI","S.D. HNDSPG","Stan.Dev. ALL"
1960     PRINT LIN(1);RPT$("-",80)
```

```
1970     PRINT Sd1,Sd2,Sd3
1980     PRINT LIN(3)
1990     PRINT "SUM (X1-avX1)^2","SUM (X2-avX2)^2"
2000     PRINT LIN(1);RPT$("-",80)
2010     PRINT Ts1,Ts2
2020     PRINT LIN(3)
2030     PRINT "T-TEST BETWEEN GROUPS"
2040     PRINT LIN(1);RPT$("-",80)
2050     PRINT Ttest
2060     PRINT LIN(1);RPT$("-",80)
2070     PRINT LIN(1);RPT$("-",80)
2080     PRINT LIN(6)
2090     PRINTER IS 16
2100 SUBEND
2110 ! File:  SUPAIR                 Cartridge: R. SHORE DATA(3)
2120 ! Date:  August 12, 1984       Author: Rick Shore
2130 ! For calculating the means and standard deviations for a series of
2140 ! various measures which are read in from files.
2150 ! A paired  t-test for dependent groups
2160 ! to compare two different groups (Somi vs Hdspg to somi) and a correlation
2170 ! is performed to compare all elements with the judged value of the move.
2180 ! Keys: STATISTICS,T-TEST,R-CORRELATION,MEAN,STANDARD DEVIATION,SHORE
2190 ! ------------------------------------------------------------------------
2200 SUB Statpr(N1,N2,A(*),Name$)
2210     DIM Dif(26),Dev(26)
2220     DIM A2(30)
2230     GOSUB Statistics
2240     GOSUB Printout
2250     END
2260 Statistics:  ! Calculations of means, standard deviations and t-test
2270     N3=N1+N2
2280     Sumdif=0
2290     Sumdev=0
2300     Stdev=0
2310     FOR I=1 TO N3-1
2320         Dif(I)=A(I,1)-A(I+1,2)   !USED FOR PAIRED T-TEST OF CORRELATED MEANS
2330         Sumdif=Sumdif+Dif(I)
2340         I=I+1
2350     NEXT I
2360     Meandif=Sumdif/N1
2370     FOR I=1 TO N3
2380         IF Dif(I)=0 THEN GOTO 2410
2390             Dev(I)=(Meandif-Dif(I))^2
2400             Sumdev=Sumdev+Dev(I)
2410     NEXT I
2420     Stdev=(Sumdev/(N1-1))^.5
2430     Sterror=Stdev/N1^.5
2440     Tsc=Meandif/Sterror
2450 Printout:   ! PRINT OUT OF ALL STATISTICAL FACTORS
2460 !   INPUT "DO YOU WANT A HARD COPY [Y/N]",H$
```

```
2470 !   IF H$="N" THEN GOTO 1300
2480         PRINTER IS 7,0
2490         FIXED 3
2500     PRINT LIN(2)
2510     PRINT Name$
2520     PRINT LIN(1);RPT$("-",25)
2530     PRINT LIN(3)
2540     PRINT "MEAN DIFFERENCE","SQ DEV ALL"
2550     PRINT LIN(1);RPT$("-",80)
2560     PRINT Meandif,Sumdev
2570     PRINT LIN(3)
2580     PRINT "ST DEV DIFFERENCES","ST ERROR MEAN DIF"
2590     PRINT LIN(1);RPT$("-",80)
2600     PRINT Stdev,Sterror
2610     PRINT LIN(3)
2620     PRINT "PAIRED T-TEST BETWEEN GROUPS"
2630     PRINT LIN(1);RPT$("-",80)
2640     PRINT Tsc
2650     PRINT LIN(1);RPT$("-",80)
2660     PRINT LIN(1);RPT$("-",80)
2670     PRINT LIN(6)
2680     PRINTER IS 16
2690 SUBEND
```

```
10   ! File: RSTATS                    Cartridge: R. SHORE DATA(3)
20   ! Date: Aug 16,1984               Author: Rick Shore
30   ! Desc: Does a bunch of stats
40   ! Keys: STATISTICS,T-TEST,MEAN,STANDARD DEVIATION,SHORE,THESIS
50   ! ---------------------------------------------------------------------
60   OPTION BASE 1
70   DIM D(13,2,11),Dfile$(13,2)[6]
80   DIM S(2,40),N(2)
90   DIM Format$[180],Descf$[160],Var$(11)
100  READ Var$(*)
110  DATA Sex,Perf,Arminc,Headinc,Trunckinc,Armvel,Headvel,Trunkvel,Score,Yforce,SMYforce
120  PRINTER IS 16
130  PRINT PAGE;
140  Numsubs=13
150  INPUT "Do you want the data ENTERED or READ IN [E,R]",Op$
160  IF Op$="E" THEN GOSUB Enterdata
170  IF Op$="R" THEN GOSUB Readin
180  INPUT "Do you want a printout of the data [Y/N]",Pr$
190  IF Pr$="Y" THEN GOSUB Printout
200  GOSUB Calculations
210  END
220 ! ---------------------------------------------------------------------
230 Enterdata:!
240  PRINTER IS 7,0,WIDTH(132)
250  FIXED 3
260  PRINT USING Headimage;"FILE","Sex","Perf","Arminc","Headinc","Trunkinc","Armvel","Headvel","Trunkvel","Sc
ore","Yforce","SMYforce"
270 Dataimage: IMAGE #,5D.3D,3X
280 Headimage: IMAGE 7A,11(12A)
290  PRINT RPT$("-",130)
300  PRINTER IS 16
310  FOR S=1 TO Numsubs
320     FOR T=1 TO 2
330        PRINT "Subject";S;"   Skill ";T
340        INPUT "Enter the file name",Dfile$(S,T)
350        PRINT Dfile$(S,T)
360        FOR V=1 TO 11
370           DISP "Enter ";Var$(V);
380           INPUT "",D(S,T,V)
390           PRINT D(S,T,V);
400        NEXT V
410        PRINT
420        PRINT "------------------------------------------"
430        PRINTER IS 7,0,WIDTH(132)
440        PRINT USING "#,4A,1X";Dfile$(S,T)
450        FOR V=1 TO 11
460           PRINT USING Dataimage;D(S,T,V)
470        NEXT V
480        PRINT
490        PRINTER IS 16
```

```
500    NEXT T
510 NEXT S
520  INPUT "Enter data file name (for storing)",File$
530  Numrecs=15
540  PAUSE
550  CREATE File$,Numrecs
560  ASSIGN #1 TO File$
570  PRINT #1;"Format$,Descr$,D(1..13,1..2,1..11),D$(1..13,1..2)[6]"
580  PRINT #1;"Stats for R SHORE THESIS"
590  PRINT #1;D(*),Dfile$(*)
600  RETURN
610 Readin:INPUT "Enter the name of the file",File$
620  ASSIGN #1 TO File$
630  READ #1;Format$,Descr$,D(*),Dfile$(*)
640  RETURN
650 Printout:!
660  PRINTER IS 7,0,WIDTH(132)
670  PRINT USING Headimage;"FILE","Sex","Perf","Arminc","Headinc","Trunkinc","Armvel","Headvel","Trunkvel","Sc
ore","Yforce","SMYforce"
680  PRINT RPT$("-",130)
690  FOR S=1 TO Numsubs
700     FOR T=1 TO 2
710        PRINT USING "#,4A,1X";Dfile$(S,T)
720        FOR V=1 TO 11
730            PRINT USING Dataimage;D(S,T,V)
740        NEXT V
750        PRINT
760     NEXT T
770  NEXT S
780  PRINTER IS 16
790  RETURN
800  ! ---------------------------------------------------------------------
810 Calculations: ! Calculates the mean and standard deviation for each set
820  FOR Ds=1 TO 2
830     PRINT PAGE;"DEFINE DATA SET:";Ds
840     PRINT LIN(1);"Sex: ";
850     INPUT "ENTER M=MALE,F=FEMALE,A=ALL",Sex$
860     PRINT Sex$;"   Type: ";
870     INPUT "ENTER SKILL TYPE H=HANDSPRING,R=RUNNING,A=ALL",Type$
880     PRINT Type$;"   Performance: ";
890     INPUT "ENTER THE PERFORMANCE VARIABLE 1=GOOD,2=BAD,0=ALL",Perf
900     PRINT Perf;"   Variable:";
910     INPUT "ENTER VARIABLE NUMBER",Vrbl
920     PRINT Vrbl;Var$(Vrbl)
930     N(Ds)=0
940     PRINTER IS 7,0,WIDTH(132)
950     PRINT "DATA SET:";Ds
960     PRINT "SEX: ";Sex$,"TYPE: ";Type$
970     PRINT "PERFORMANCE:";Perf,"VARIABLE:";Vrbl;Var$(Vrbl);LIN(1)
980     FOR S=1 TO Numsubs
```

```
990       FOR T=1 TO 2
1000         IF Type$="A" THEN GOTO 1030
1010           IF (Type$="H") AND (T=1) THEN GOTO 1150
1020           IF (Type$="R") AND (T=2) THEN GOTO 1150
1030         FOR V=3 TO 11
1040           IF Sex$="A" THEN GOTO 1070
1050             IF (Sex$="M") AND (D(S,T,1)=2) THEN GOTO 1140
1060             IF (Sex$="F") AND (D(S,T,1)=1) THEN GOTO 1140
1070           IF Perf=0 THEN GOTO 1100
1080             IF (Perf=1) AND (D(S,T,2)=2) THEN GOTO 1140
1090             IF (Perf=2) AND (D(S,T,2)=1) THEN GOTO 1140
1100           IF Vrbl()V THEN GOTO 1140
1110             N(Ds)=N(Ds)+1
1120             S(Ds,N(Ds))=D(S,T,V)
1130             PRINT N(Ds),S(Ds,N(Ds))
1140         NEXT V
1150       NEXT T
1160     NEXT S
1170     PRINT RPT$("-",40);LIN(1)
1180     DISP "press CONTINUE"
1190     PAUSE
1200     PRINTER IS 16
1210 NEXT Ds
1220 CALL Stats(N(*),S(*),Var$(Vrbl))
1230 CALL Indep(N(*),S(*),Var$(Vrbl))
1240 CALL Dep(N(*),S(*),Var$(Vrbl))
1250 PRINT LIN(2)
1260 GOTO Calculations
1270 End: !
1280 ! ---------------------------------------------------------------
1290 !
1300 !
1310 !
1320 SUB Indep(N(*),A(*),Name$)
1330     FOR I=1 TO 2
1340        S(I)=0
1350        FOR J=1 TO N(I)
1360           S(I)=S(I)+A(I,J)
1370        NEXT J
1380        Mean(I)=S(I)/N(I)
1390        X2(I)=0
1400        FOR J=1 TO N(I)
1410           X2(I)=X2(I)+(Mean(I)-A(I,J))^2
1420        NEXT J
1430     NEXT I
1440     Ss=SQR((X2(1)+X2(2))/(N(1)-1+(N(2)-1)))
1450     Sd=Ss*SQR((N(1)+N(2))/(N(1)*N(2)))
1460     T=(Mean(1)-Mean(2))/Sd
1470     PRINTER IS 7,0
1480     FIXED 4
```

```
1490     PRINT "INDEPENDENT T-TEST: ";Name$
1500     PRINT "     Ss";Ss,"Sd";Sd,"T";T
1510     PRINTER IS 16
1520 SUBEND
1530 !
1540 !
1550 !
1560 SUB Dep(N(*),A(*),Name$)
1570     DIM Dif(26),Dev(26)
1580 Statistics:  ! Calculations of means, standard deviations and t-test
1590     Sumdif=0
1600     Sumdev=0
1610     Stdev=0
1620     FOR I=1 TO N(1)
1630         Dif(I)=A(1,I)-A(2,I)   !USED FOR PAIRED T-TEST OF CORRELATED MEANS
1640         Sumdif=Sumdif+Dif(I)
1650         I=I+1
1660     NEXT I
1670     Meandif=Sumdif/N(1)
1680     FOR I=1 TO N(1)
1690         Dev(I)=(Meandif-Dif(I))^2
1700         Sumdev=Sumdev+Dev(I)
1710     NEXT I
1720     Stdev=(Sumdev/(N(1)-1))^.5
1730     Sterror=Stdev/N(1)^.5
1740     Tsc=Meandif/Sterror
1750     PRINTER IS 7,0,WIDTH(132)
1760     FIXED 4
1770     PRINT "DEPENDENT T-TEST:  ";Name$
1780     PRINT "     Mean Diff";Meandif;"  Sq Dev";Sumdev;
1790     PRINT "  St Dev";Stdev;"  St Err";Sterror;
1800     PRINT "  Paired-t";Tsc
1810     PRINTER IS 16
1820 SUBEND
1830 !
1840 !
1850 !
1860 SUB Stats(N(*),A(*),Name$)
1870 PRINTER IS 7,0,WIDTH(132)
1880 PRINT "GENERAL STATS: ";Name$
1890 FIXED 4
1900 FOR I=1 TO 2
1910     PRINT "     ";
1920     S=0
1930     Sq=0
1940     FOR J=1 TO N(I)
1950        S=S+A(I,J)
1960        Sq=Sq+A(I,J)^2
1970     NEXT J
1980     M=S/N(I)
```

```
1990     V=(Sq-S^2/N(I))/(N(I)-1)
2000     Sd=SQR(V)
2010     PRINT "Data set";I,"Mean:";M,"Variance:";V,"St.Dev";Sd
2020 NEXT I
2030 SUBEND
```

```
10   ! File: XYCG4                    Cartridge: R. SHORE THESIS (1)
20   ! Date: June, 1983               Author: P.J.Thiessen
30   ! Desc: This program was originally XYCG3, but has been modified to store
40   ! each frame's data in one record so that the frames can be read in at
50   ! any point.
60   ! Keys: C OF G,DIG,PLOT,DIGITIZE,COORDINATES,STICK
70   ! -------------------------------------------------------------------
80   INTEGER Xpt(100,30),Ypt(100,30),Xcofg(100),Ycofg(100),Numfrms,Numpts
90   INTEGER Descode(100)
100  DIM T$[100],P$(30)[30],X$[25],Descrfilm$[180],File$[6]
110  PRINTER IS 16
120  PRINT PAGE;LIN(7);TAB(19);" XY COORDINATE AND CENTER OF GRAVITY PROGRAM "
130  PRINT LIN(2);TAB(29);"(Updated November, 1982)"
140  Select=706
150  OUTPUT Select;"IN"
160  V$=""
170  LINPUT "Please enter a description of the film to be digitized [eg. Subject name,etc.]",Descrfilm$
180  INPUT "How many frames do you want to digitize [max. 100]",Numfrms
190  Numpts=21
200  INPUT "How many points per frame [default = 21, max. 30]",Numpts
210  INPUT "Do you want the C. of G.'s calculated [Y/N]",Cg$
220  W=1
230  IF Cg$="Y" THEN INPUT "Which C of G program; 1,2 or 3  [default=1]",W
240  INPUT "Do you want to point align or axis align [P/A]",Al$
250  INPUT "NOTE: Has the printer been turned on line [Y/N]",T$
260  IF T$<>"Y" THEN GOTO 250
270  INPUT "Do you want to calculate film speed [Y/N]",Fs$
280  IF Fs$<>"Y" THEN GOTO 310
290      GOSUB Filmspeed
300  GOTO 370
310      INPUT "What is the time between frames",Time
320      INPUT "Are you digitizing every frame, every 2nd, 3rd.... (enter 1 or 2,etc.)",Every
330      Time=Time*Every
340      INPUT "Do you want to scale the film [Y/N]",Sc$
350      IF Sc$="Y" THEN GOSUB Scale
360      IF Sc$="N" THEN INPUT "Please enter the scaling factor",Cfact
370  IF Cfact=0 THEN Cfact=1
380  PRINT PAGE
390  Cf$="Y"
400  ! INPUT "Do you want to confirm the digitizing by having the frame plotted [Y/N]",Cf$
410  GOSUB Getname
420  OUTPUT Select;"IN;SG;AT"
430  Inputmode=Flip=1
440  Correcting=0
450  DISP
460  FOR Frame=1 TO Numfrms
470 Begin:!
480      GOSUB Seehp
490      DISP "FRAME: ";Frame
500      OUTPUT Select;"DF;SG"
```

```
510      IF A1$="P" THEN GOSUB Pointalign
520      IF A1$="A" THEN GOSUB Axisalign
530      Lastpoint=1
540      Point=1
550          GOSUB Getpoint
560          Xpt(Frame,Point)=X-Xconv
570          Ypt(Frame,Point)=Y-Yconv
580          Point=Point+1
590          IF Point>Lastpoint THEN Lastpoint=Point
600          IF Point>Numpts THEN GOTO 620
610          GOTO 550
620      GOSUB Accept_reject
630      IF Ar$="R" THEN GOTO 480
640      IF Correcting THEN RETURN
650  NEXT Frame
660 Exitloop:!
670  GOSUB Digfinish
680  GOSUB Correct
690  Inputmode=0
700  IF UPC$(Cg$)="Y" THEN GOSUB Cofg_link
710  PRINTER IS 16
720  PRINT PAGE
730  INPUT "Do you want this data stored [Y/N]",Store$
740  IF Store$="Y" THEN GOSUB Store
750  IF (Store$<>"Y") OR (UPC$(P$)="Y") THEN GOTO 770
760      PRINT LIN(2);"DATA STORED IN FILE NAMED: ";File$
770  GOSUB Hpbeep
780  IF Store$="N" THEN GOTO 910
790      DISP "READY TO LABEL THE TRACINGS -- press the CONTINUE key"
800      PAUSE
810      PLOTTER IS 7,5,"9872A"
820      SCALE 0,2,0,2
830      DISP "Please move the pen to an open spot on the paper, then press CONTINUE"
840      PAUSE
850      CURSOR A,B
860      MOVE A,B
870      LORG 4
880      LABEL File$
890      LINPUT "Label again? (for more than one page) [Y/N]",Lag$
900      IF Lag$="Y" THEN GOTO 830
910  DISP "Program XYCG3 completed"
920  END
930  ! -----------------------------------------------------------------------
940  !                            S U B R O U T I N E S
950  ! -----------------------------------------------------------------------
960 Getname: RESTORE Codes
970        FOR I=1 TO Numpts
980            READ A$,B$,C$
990            P$(I)=";DD11,"&A$&";DD12,"&B$&";DD13,"&C$
1000       NEXT I
```

```
1010       RESTORE Names
1020       PRINT "JOINT POINT CODE NAMES:";LIN(1)
1030       Switch=-1
1040       FOR I=1 TO 21
1050          Switch=Switch*-1
1060          READ X$
1070          IF (I()11) AND (I()6) THEN PRINT I;") ";X$,,
1080          IF (I=11) OR (I=6) THEN PRINT I;") ";X$,
1090          IF Switch(0 THEN PRINT
1100       NEXT I
1110       PRINT "all additional points = P1, P2, P3, etc."
1120       PRINT LIN(1);"DIGITIZER KEY CONTROLS:";LIN(1)
1130       PRINT "fa -- accept, or continue *       fb -- reject        fc -- back one point"
1140       PRINT "fd -- ahead one point             fe -- no action"
1150       PRINT LIN(1);" * Note:  Key 'fa' must be pressed to continue after axis align"
1160       RETURN
1170       ! THESE ARE THE CODES FOR EACH POINT TO BE DIGITIZED!
1180 Codes:DATA 204,142,246,204,204,30,204,158,28,204,182,110,182,30,204
1190       DATA 30,110,252,28,182,110,28,158,28,28,204,30,28,142,246,156,110,206
1200       DATA  204,110,206,204,236,158,204,238,236,204,110,28,204,30,252
1210       DATA  28,110,206,28,236,158,28,238,236,28,110,28,28,30,252,206,12,0
1220       DATA  206,218,0,206,242,0,206,102,0,206,182,0,206,190,0
1230 Names:DATA RFG= R.Finger,RRT= R.Wrist,REL= R.Elbow,RSH= R.Shoulder
1240       DATA STR= Sternum,THD= Top of Head,LSH= L.Shoulder,LEL=L.Elbow
1250       DATA LRT= L.Wrist,LFG= L.Fingers,CHP= Center of hips,RHP= R. Hip
1260       DATA RNE= R. Knee,RAN= R. Ankle,RHL= R. Heel,RTO= R. Toe,LHP= L. Hip
1270       DATA LNE= L. Knee,LAN= L. Ankle,LHL= L. Heel,LTO= L. Toe
1280 ! ------------------------------------------------------------------------
1290 Getpoint: IF NOT Inputmode OR Axisalign OR Pointalign THEN 1330
1300       OUTPUT Select USING 1310;Frame,Point         ! Display frame and
1310       IMAGE "LB",XXXDD,XXDD                        ! point CODE
1320       OUTPUT Select;"DD1,142;DD2,204"&P$(Point)
1330       OUTPUT Select;"OS"
1340          WAIT 10
1350          ENTER Select;Status
1360          IF BIT(Status,7) AND Inputmode THEN Keys ! If key pressed
1370          IF BIT(Status,2)=0 THEN Getpoint          ! goto Keys
1380       OUTPUT Select;"OD"
1390       ENTER Select;X,Y,Descode(Frame)
1400       X=17400-X
1410       OUTPUT Select;"BP75,200"
1420       RETURN
1430 Keys: OUTPUT Select;"OK"                           ! Output keys
1440       ENTER Select;Key                             ! Enter keys
1450       IF (Key()4) AND (Key()8) THEN GOTO 1560
1460       IF Key=4 THEN Point=Point-1                  ! KEY 'fc'!
1470       IF Point(1 THEN Point=1                      ! go back 1 point
1480       IF Key=4 THEN GOTO 1500                      ! -------------------
1490       IF Key=8 THEN Point=Point+1                  ! KEY 'fd'!
1500       IF Point)Lastpoint THEN Point=Lastpoint      ! go forward 1 point
```

```
1510        OUTPUT Select;"BP101,50"                    ! ------------------
1520        WAIT 100
1530        OUTPUT Select;"BP"
1540        WAIT 100
1550        OUTPUT Select;"BP"
1560        OUTPUT Select;"SK0"                         ! Clear keys
1570        GOTO Getpoint
1580 ! ---------------------------------------------------------------------
1590 Correct:!
1600        INPUT "Do you want to correct any frames [Y/N]",Cr$
1610        IF Cr$="N" THEN RETURN
1620        OUTPUT Select;"IN;SG"
1630        Inputmode=1
1640        Correcting=1
1650 Cloop:Frame=0
1660        INPUT "Enter the number of the frame to be corrected (enter 0 to go on)",Frame
1670        IF Frame<=0 THEN Cexit
1680        GOSUB Begin
1690        GOTO Cloop
1700 Cexit:Correcting=0
1710        INPUT "I assume that all the data is now correct and you want to go on [Y/N]",Go$
1720        IF Go$<>"Y" THEN GOTO Cloop
1730        RETURN
1740 ! ---------------------------------------------------------------------
1750 Store:INPUT "Enter a name for the data file [maximum of 6 characters]",File$
1760        Numrecs=Numfrms+2
1770        ON ERROR GOTO Storerror
1780        DISP "Please insert the data cartridge -- then press 'CONTINUE'"
1790        PAUSE
1800        DISP "";File$;" is being created"
1810        CREATE File$,Numrecs,180
1820        ASSIGN #1 TO File$
1830        DISP "Data is being stored in ";File$;""
1840        PRINT #1;"Format$,Descfilm$,Numfrms,Numpts,Cfact,Time,[F=1:Numfrms (Coord(F,1:Numpts,1:2),Cofg(F,1:
2),Descode(F)]"
1850        PRINT #1;Descrfilm$
1860        PRINT #1;Numfrms,Numpts
1870        PRINT #1;Cfact
1880        PRINT #1;Time
1890        FOR Frame=1 TO Numfrms
1900            PRINT #1,Frame+2
1910            FOR Point=1 TO Numpts
1920                PRINT #1;Xpt(Frame,Point),Ypt(Frame,Point)
1930            NEXT Point
1940            PRINT #1;Xcofg(Frame),Ycofg(Frame),Descode(Frame)
1950        NEXT Frame
1960        ASSIGN * TO #1
1970        DISP "Data storage completed"
1980        WAIT 1000
1990        RETURN
```

```
2000 Storerror:!
2010       BEEP
2020       IF (ERRN<>64) AND (ERRN<>55) THEN GOTO 2050
2030           DISP "ERROR -- not enough room on this tape (Please insert another then CONTINUE)"
2040           GOTO 1790
2050       IF ERRN<>80 THEN GOTO 2080
2060           DISP "ERROR -- cartridge not inserted (properly) (Insert and press CONTINUE)"
2070           GOTO 1790
2080       IF (ERRN<>53) AND (ERRN<>54) THEN GOTO 2110
2090           EDIT "ERROR -- improper or duplicate file name (Enter a new file name)",File$
2100           GOTO 1800
2110       PRINT PAGE;" ERROR -- an error has occurred while trying to store data"
2120       PRINT LIN(1);"          Please do not turn off computer !!  If possible, get assistance"
2130       PRINT "          in handling this error.  If you cannot get assistance, leave the"
2140       PRINT "          computer on and the problem will be handled as soon as possible.";LIN(1)
2150       PRINT "          (Error message: ";ERRM$;" )"
2160       ON KBD GOTO 2190 ,ALL
2170       DISP "NOTE: Only the PAUSE key will pause this program (all other keys disabled)"
2180       GOTO 2180
2190       K$=KBD$
2200       K=0
2210       IF LEN(K$)=2 THEN K=NUM(K$[2])
2220       IF K=17 THEN GOTO 2250
2230       BEEP
2240       GOTO 2160
2250       DISP "PROGRAM PAUSED -- press CONTINUE to return to error trap"
2260       PAUSE
2270       GOTO 2050
2280 ! ---------------------------------------------------------------------
2290 Accept_reject:!
2300       GOSUB Seehp
2310       IF Cf$="Y" THEN GOSUB Plotpoints
2320       LINPUT "Do you want to Accept or reject [enter A/R]",Ar$
2330       IF (Ar$="A") OR (Ar$="R") THEN GOTO 2360
2340           BEEP
2350           GOTO 2320
2360       RETURN
2370 ! ---------------------------------------------------------------------
2380 Plotpoints:!
2390       DISP "READY TO PLOT  -- press 'CONTINUE' to begin plotting"
2400       GOSUB Hpbeep
2410       PAUSE
2420       PLOTTER IS 7,5,"9872A"
2430       STATUS 7,5;Plotstat
2440       IF NOT BIT(Plotstat,7) THEN GOTO 2480
2450           BEEP
2460           DISP "Please turn OFF the CHART LOAD button"
2470           GOTO 2430
2480       DISP
2490       SCALE 0,17400,0,13500
```

```
2500       Flip=Flip*-1
2510       IF Flip<0 THEN LINE TYPE 1,4
2520       IF Flip>0 THEN LINE TYPE 4,1
2530       RESTORE Order1       ! Normal plotting order
2540   !   RESTORE Order2       ! Special plotting order (no lower leg)
2550       FOR Pt=1 TO Numpts+3
2560          READ C
2570          IF C>0 THEN GOTO 2600
2580             PENUP
2590             GOTO 2560
2600          PLOT Xpt(Frame,C),Ypt(Frame,C)
2610          DISP Xpt(Frame,C),Ypt(Frame,C)
2620       NEXT Pt
2630       PENUP
2640       RETURN
2650 Order1: DATA 1,2,3,4,5,6,-1,5,7,8,9,10,-1,5,11,12,13,14,15,16,-1,11,17,18,19,20,21,-1,22,23,24,25,26
2660 Order2: DATA 1,2,3,4,5,6,-1,5,7,8,9,10,-1,5,11,12,13,-1,11,14,15
2670 ! ----------------------------------------------------------------------
2680 Cofg_link:   DISP "THE C OF G SUBPROGRAM IS BEING LOADED -- PLEASE WAIT"
2690  !    IF W=1 THEN LINK "Cofg1",End,2320
2700       IF W=2 THEN LINK "Cofg2",End,2720
2710       IF W=3 THEN LINK "Cofg3",End,2720
2720       IF W=1 THEN CALL Cofg1(Xpt(*),Ypt(*),Xcofg(*),Ycofg(*),Numfrms,Numpts)
2730       IF W=2 THEN CALL Cofg2(Xpt(*),Ypt(*),Xcofg(*),Ycofg(*),Numfrms,Numpts)
2740       IF W=3 THEN CALL Cofg3(Xpt(*),Ypt(*),Xcofg(*),Ycofg(*),Numfrms,Numpts)
2750       RETURN
2760 ! ----------------------------------------------------------------------
2770 Digfinish:OUTPUT Select;"BP"
2780       OUTPUT Select;"DD1,252;DD2,12;DD3,246;DD4,1"
2790       WAIT 200
2800       OUTPUT Select;"BP"
2810       OUTPUT Select;"DD5,0;DD6,142;DD7,12;DD8,236;DD9,12;DD10,182;DD11,110;DD12,158;DD13,252"
2820       WAIT 200
2830       OUTPUT Select;"BP"
2840       RETURN
2850 ! ----------------------------------------------------------------------
2860 Pointalign:Pointalign=1
2870       OUTPUT Select;"IN;SG;BP"
2880       IF Frame>0 THEN OUTPUT Select USING "AA,XXXXXXXXXXDZ";"LB",Frame
2890       OUTPUT Select;"DD1,206;DD2,1;DD3,0;DD4,238;DD5,28;DD6,12;DD7,246;DD8,236"
2900       GOSUB Getpoint
2910       Ox=X
2920       Oy=Y
2930       GOSUB Getpoint
2940       Tx=X
2950       Ty=Y
2960       Xconv=Tx-Ox
2970       Yconv=Ty-Oy
2980       Pointalign=0
2990       RETURN
```

```
3000 ! -------------------------------------------------------------------------
3010 Axisalign:Axisalign=1
3020       OUTPUT Select;"BP"
3030       WAIT 200
3040       OUTPUT Select;"BP"
3050       WAIT 200
3060       OUTPUT Select;"BP"
3070       OUTPUT Select USING "AA,XXXXXXXXXXDZ";"LB",Frame
3080       OUTPUT Select;"DD1,238;DD2,1;DD3,0;DD4,238;DD5,28;DD6,12;DD7,246;DD8,236"
3090       OUTPUT Select;"AA"
3100       OUTPUT Select;"SK0"
3110       OUTPUT Select;"OK"
3120       ENTER Select;Key
3130           IF Key=1 THEN GOTO 3150
3140           GOTO 3110
3150       Xconv=Yconv=0
3160       OUTPUT Select;"SG"
3170       Axisalign=0
3180       RETURN
3190 Image2:IMAGE "LB",DDDZ.DDDD
3200 ! -------------------------------------------------------------------------
3210 Scale:OUTPUT Select;"IN;SG;AT"
3220       PRINT PAGE
3230       DISP "DIGITIZER READY TO SCALE -- please digitize 2 points."
3240       FOR C=1 TO 2
3250           OUTPUT Select;"BP"
3260           OUTPUT Select USING 3270;C
3270           IMAGE "LB",9XD
3280           OUTPUT Select;"DD1,182;DD2,156;DD3,238;DD4,28;DD5,158;DD7,206;DD8,30"
3290           GOSUB Getpoint
3300           Sx(C)=X
3310           Sy(C)=Y
3320       NEXT C
3330       OUTPUT Select;"BP"
3340       WAIT 200
3350       OUTPUT Select;"BP"
3360       OUTPUT Select;"IN;SG"
3370       OUTPUT Select;"DD1,238;DD2,156;DD3,30;DD4,124;DD5,238;DD6,28"
3380       GOSUB Getannot
3390       Actual=Annot
3400       IF Actual=0 THEN GOTO 3350
3410       Digdist=SQR((Sx(2)-Sx(1))^2+(Sy(2)-Sy(1))^2)
3420       Cfact=Actual/Digdist
3430       DISP "C. FACTOR: ";Cfact;
3440       OUTPUT Select USING 3450;Cfact
3450       IMAGE "LB",XXXXXZ.DDDE
3460       GOSUB A_r
3470       IF Ar<0 THEN GOTO Scale
3480       OUTPUT Select;"LB"
3490       IF Rs$="Y" THEN GOTO Scale
```

```
3500      RETURN
3510 Hpbeep:FOR B=1 TO 10
3520          BEEP
3530          WAIT 50
3540      NEXT B
3550      RETURN
3560 Getannot:!
3570      OUTPUT Select;"OS"
3580          ENTER Select;Status
3590          IF NOT BIT(Status,0) THEN GOTO Getannot
3600      OUTPUT Select;"ON"
3610      ENTER Select;Annot
3620      RETURN
3630 A_r:  Ar=0
3640      OUTPUT Select;"DD1,238;DD2,2;DD3,204"
3650      OUTPUT Select;"SK0"
3660      OUTPUT Select;"OS"
3670          ENTER Select;Status
3680          IF NOT BIT(Status,7) THEN GOTO 3660
3690      OUTPUT Select;"OK"
3700      ENTER Select;Key
3710      IF Key=1 THEN Ar=1
3720      IF Key=2 THEN Ar=-1
3730      IF Ar=0 THEN OUTPUT Select;"BP"
3740      IF Ar=0 THEN GOTO 3650
3750      RETURN
3760 ! ----------------------------------------------------------------------
3770 Filmspeed:!
3780      PRINTER IS 16
3790      Fball=10  ! NOTE: Number of frames between ball positions
3800      INPUT "Do you want to scale the film [Y/N]",Sc$
3810      IF Sc$="Y" THEN GOSUB Scale
3820      IF Cfact=0 THEN Cfact=1
3830      IF Sc$<>"Y" THEN RETURN
3840      GOSUB Fsexplain
3850      OUTPUT Select;"DD1,158;DD2,236;DD3,30;DD4,158;DD5,204;DD7,142;DD8,1;DD9,182;DD10,206;DD11,158;DD12,
158;DD13,252"
3860      GOSUB Getannot
3870      Assumed_t=Annot
3880      GOSUB Filmaccel
3890      OUTPUT Select;"BP"
3900      WAIT 200
3910      OUTPUT Select;"BP"
3920      WAIT 200
3930      OUTPUT Select;"BP"
3940      OUTPUT Select USING 3950;Time
3950      IMAGE "LB",5XZ.DDDDDD
3960      GOSUB A_r
3970      IF Ar<0 THEN GOTO 3810
3980      GOSUB Seehp
```

```
3990      GOSUB Hpbeep
4000      INPUT "Are you digitizing every frame, every 2nd, etc [enter 1,2, or 3]",Frameincr
4010      Time=Time*Frameincr
4020      GOSUB Printspeed
4030      RETURN
4040 Beepbeep:OUTPUT Select;"BP"
4050      WAIT 200
4060      OUTPUT Select;"BP"
4070      RETURN
4080 Seehp:OUTPUT Select;"LB"
4090      OUTPUT Select;"DD1,182;DD2,158;DD3,158;DD5,110;DD6,206;DD7,1;DD8,1;DD9,1;DD10,1"
4100      RETURN
4110 Filmaccel:DISP "Please align each frame and digitize the bottom of the ball"
4120      GOSUB Beepbeep
4130      IF Al$="P" THEN GOSUB Pointalign
4140      IF Al$="A" THEN GOSUB Axisalign
4150      OUTPUT Select USING Image;1
4160      OUTPUT Select;"DD1,142;DD2,204;DD3,0"
4170      GOSUB Getpoint
4180      X1=X-Xadjust
4190      Y1=Y-Yadjust
4200      GOSUB Beepbeep
4210      IF Al$="P" THEN GOSUB Pointalign
4220      IF Al$="A" THEN GOSUB Axisalign
4230      OUTPUT Select USING Image;2
4240      OUTPUT Select;"DD1,142;DD2,204;DD3,0"
4250      GOSUB Getpoint
4260      X2=X-Xadjust
4270      Y2=Y-Yadjust
4280      GOSUB Beepbeep
4290      IF Al$="P" THEN GOSUB Pointalign
4300      IF Al$="A" THEN GOSUB Axisalign
4310      OUTPUT Select USING Image;3
4320      OUTPUT Select;"DD1,142;DD2,204;DD3,0"
4330      GOSUB Getpoint
4340      X3=X-Xadjust
4350      Y3=Y-Yadjust
4360      Vel1=SQR((X2-X1)^2+(Y2-Y1)^2)*Cfact/(Assumed_t*Fball)
4370      Vel2=SQR((X3-X2)^2+(Y3-Y2)^2)*Cfact/(Assumed_t*Fball)
4380      Accel=(Vel2-Vel1)/(Assumed_t*Fball)
4390      Ratio=Accel/9.81
4400      Time=Assumed_t*Ratio
4410      PRINT LIN(1);"Parameter","   Assumed","   Actual"
4420      PRINT "---------","   -------","   ------";LIN(1)
4430      PRINT "Initial V",Vel1,SQR((X2-X1)^2+(Y2-Y1)^2)*Cfact/(Time*Fball)
4440      PRINT "Final   V",Vel2,SQR((X3-X2)^2+(Y3-Y2)^2)*Cfact/(Time*Fball)
4450      PRINT "Accel",Accel,9.81;LIN(1)
4460      PRINT "TIME",Assumed_t,Time;LIN(1)
4470      PRINT "RATIO: ";Ratio,"CONVERSION FACTOR: ";Cfact;LIN(2)
4480 Image:IMAGE "LB",XXXXD
```

```
4490       RETURN
4500 ! ======================================================================
4510 Fsexplain:!
4520       PRINT PAGE;"      FILM SPEED ANALYSIS";LIN(2)
4530       PRINT "INSTRUCTIONS:";LIN(1);"=============";LIN(1)
4540       PRINT "A) For three frames (every ";VAL$(Fball);"th frame):"
4550       PRINT "     1) The digitizer will beep twice, this signals that you must align your"
4560       PRINT "            film.  This may be done using the point align or axis align "
4570       PRINT "            procedure depending on your earlier choice."
4580       PRINT "     2) Next you must digitize the bottom of the ball in each frame.  "
4590       PRINT "            Remember to use every ";VAL$(Fball);"th frame when digitizing the ball."
4600       PRINT "B) The positions of the ball in the three frames will then be used to "
4610       PRINT "       calculate the acceleration of the ball using the time that you entered"
4620       PRINT "C) The actual time between frames will be calculated by using the ratio of"
4630       PRINT "       the calculated acceleration over actual acceleration [ 9.81 m/s/s ]"
4640       PRINT "       using your assumed time."
4650       DISP "SEE DIGITIZER ...."
4660       RETURN
4670 ! ======================================================================
4680 Printspeed:!
4690       INPUT "Do you want the output on paper [Y/N] TURN PRINTER ON-LINE",P$
4700       IF P$="Y" THEN PRINTER IS 7,0,WIDTH(132)
4710       PRINT Descrfilm$;LIN(1);RPT$("=",LEN(Descrfilm$));LIN(2);"FILM SPEED CALCULATION:"
4720       PRINT LIN(1);"Parameter","    Assumed","    Actual"
4730       PRINT "---------","    -------","    ------";LIN(1)
4740       PRINT "Initial V",Vel1,SQR((X2-X1)^2+(Y2-Y1)^2)*Cfact/(Time*10)
4750       PRINT "Final   V",Vel2,SQR((X3-X2)^2+(Y3-Y2)^2)*Cfact/(Time*10)
4760       PRINT "Accel",Accel,(Vel2-Vel1)/(Time*10);LIN(1)
4770       PRINT "TIME",Assumed_t,Time/Frameincr;LIN(1)
4780       PRINT "RATIO: ";Ratio,"CONVERSION FACTOR: ";Cfact
4790       PRINT LIN(1);"Every";Frameincr;" frames, time increment:";Time;LIN(3)
4800       PRINTER IS 16
4810       IF P$="Y" THEN GOTO 4840
4820          DISP "Please press 'CONTINUE' to begin digitizing"
4830          PAUSE
4840       RETURN
4850 ! ======================================================================
4860 End:!
4870 SUB Cofg1(INTEGER Xcoord(*),Ycoord(*),Xcofg(*),Ycofg(*),Totfrms,Numjts)
4880 MAT Xcofg=ZER
4890 MAT Ycofg=ZER
4900 INTEGER Xmoment(15),Ymoment(15),Xseg(15),Yseg(15)
4910 SHORT Segwt(15)
4920 DIM Title$[100]
4930 !
4940 PRINTER IS 16
4950 PRINT PAGE;TAB(20);"CENTER OF GRAVITY ANALYSIS PROGRAM ONE";LIN(2)
4960 PRINT "PRINT OUT OPTIONS:";LIN(1)
4970 PRINT "(1) Complete printout of all data including:";LIN(1)
4980 PRINT "     (a) Segment C of G coordinates"
```

```
4990 PRINT "     (b) Segment Weightings"
5000 PRINT "     (c) Segment Moments"
5010 PRINT "     (d) Final Summary (see below)";LIN(2)
5020 PRINT "(2) Print out a list of the C of G's for each frame (Final Summary)"
5030 INPUT "Please enter the number of the print out option desired [1 or 2]",Prnt
5040 INPUT "Do you want the print out on paper [Y/N]",P$
5050 IF P$="Y" THEN PRINTER IS 7,0,WIDTH(135)
5060 !
5070 GOSUB Setup
5080 FOR F=1 TO Totfrms
5090     GOSUB Segcofg
5100     GOSUB Cofgcalc
5110     IF Prnt=1 THEN GOSUB Printout
5120 NEXT F
5130 GOSUB Summary
5140 WAIT 2000
5150 SUBEND
5160 ! ========================================================================
5170 !                                SUBROUTINES
5180 ! ========================================================================
5190 Setup:   !  SETUP SPECIFIES THE SEGMENT WEIGHTINGS
5200       INPUT "Is the subject Male or Female [M/F]",S$
5210       IF (S$<>"M") AND (S$<>"F") THEN BEEP
5220       IF (S$<>"M") AND (S$<>"F") THEN GOTO 5200
5230       IF S$="F" THEN GOTO 5420
5240       ! --------------------------------------------
5250       !             M A L E   S U B J E C T
5260       ! --------------------------------------------
5270       Segwt(1)=.0065       ! R. HAND
5280       Segwt(2)=.019        ! R. FOREARM
5290       Segwt(3)=.033        ! R. UPPERARM
5300       Segwt(4)=.096        ! HEAD AND NECK
5310       Segwt(5)=.033        ! L. UPPERARM
5320       Segwt(6)=.019        ! L. FOREARM
5330       Segwt(7)=.0065       ! L. HAND
5340       Segwt(8)=.458        ! TRUNK
5350       Segwt(9)=.105        ! R. THIGH
5360       Segwt(10)=.045       ! R. LEG (SHANK)
5370       Segwt(11)=.0145      ! R. FOOT
5380       Segwt(12)=.105       ! L. THIGH
5390       Segwt(13)=.045       ! L. LEG
5400       Segwt(14)=.0145      ! L. FOOT
5410       GOTO 5600
5420       ! --------------------------------------------
5430       !         F E M A L E   S U B J E C T
5440       ! --------------------------------------------
5450       Segwt(1)=.005        ! R. HAND
5460       Segwt(2)=.0155       ! R. FOREARM
5470       Segwt(3)=.03         ! R. UPPERARM
5480       Segwt(4)=.077        ! HEAD AND NECK
```

```
5490      Segwt(5)=.03         ! L. UPPERARM
5500      Segwt(6)=.0155       ! L. FOREARM
5510      Segwt(7)=.005        ! L. HAND
5520      Segwt(8)=.463        ! TRUNK
5530      Segwt(9)=.115        ! R. THIGH
5540      Segwt(10)=.0525      ! R. LEG (SHANK)
5550      Segwt(11)=.012       ! R. FOOT
5560      Segwt(12)=.115       ! L. THIGH
5570      Segwt(13)=.0525      ! L. LEG (SHANK)
5580      Segwt(14)=.012       ! L. FOOT
5590      ! -------------------------------------------
5600      Numsegs=14
5610      INPUT "Is there an implement being used (eg. racquet, bat, ball, etc) [Y/N]",Add$
5620      IF Add$="Y" THEN GOSUB Implement
5630      RETURN
5640 ! -------------------------------------------------------------------------
5650 Segcofg: !    SEGCOFG CALCULATES THE SEGMENTAL C OF G'S
5660      Xseg(1)=.28*(Xcoord(F,2)-Xcoord(F,1))+Xcoord(F,1)  !R. HAND
5670      Yseg(1)=.28*(Ycoord(F,2)-Ycoord(F,1))+Ycoord(F,1)
5680      Xseg(2)=.43*(Xcoord(F,3)-Xcoord(F,2))+Xcoord(F,2)  !R. FOREARM
5690      Yseg(2)=.43*(Ycoord(F,3)-Ycoord(F,2))+Ycoord(F,2)
5700      Xseg(3)=.436*(Xcoord(F,4)-Xcoord(F,3))+Xcoord(F,3) !R.UPPERARM
5710      Yseg(3)=.436*(Ycoord(F,4)-Ycoord(F,3))+Ycoord(F,3)
5720      Xseg(4)=.500*(Xcoord(F,6)-Xcoord(F,5))+Xcoord(F,5) ! HEAD&NECK
5730      Yseg(4)=.500*(Ycoord(F,6)-Ycoord(F,5))+Ycoord(F,5)
5740      Xseg(5)=.436*(Xcoord(F,7)-Xcoord(F,8))+Xcoord(F,8) !L.UPPERARM
5750      Yseg(5)=.436*(Ycoord(F,7)-Ycoord(F,8))+Ycoord(F,8)
5760      Xseg(6)=.43*(Xcoord(F,8)-Xcoord(F,9))+Xcoord(F,9)  !L. FOREARM
5770      Yseg(6)=.43*(Ycoord(F,8)-Ycoord(F,9))+Ycoord(F,9)
5780      Xseg(7)=.28*(Xcoord(F,9)-Xcoord(F,10))+Xcoord(F,10)  ! L. HAND
5790      Yseg(7)=.28*(Ycoord(F,9)-Ycoord(F,10))+Ycoord(F,10)
5800      Xseg(8)=.500*(Xcoord(F,11)-Xcoord(F,5))+Xcoord(F,5)    ! TRUNK
5810      Yseg(8)=.500*(Ycoord(F,11)-Ycoord(F,5))+Ycoord(F,5)
5820      Xseg(9)=.433*(Xcoord(F,13)-Xcoord(F,12))+Xcoord(F,12)  !R THIGH
5830      Yseg(9)=.433*(Ycoord(F,13)-Ycoord(F,12))+Ycoord(F,12)
5840      Xseg(10)=.433*(Xcoord(F,14)-Xcoord(F,13))+Xcoord(F,13) !R LEG
5850      Yseg(10)=.433*(Ycoord(F,14)-Ycoord(F,13))+Ycoord(F,13)
5860      Xseg(11)=.450*(Xcoord(F,16)-Xcoord(F,15))+Xcoord(F,15) !R FOOT
5870      Yseg(11)=.450*(Ycoord(F,16)-Ycoord(F,15))+Ycoord(F,15)
5880      Xseg(12)=.433*(Xcoord(F,18)-Xcoord(F,17))+Xcoord(F,17) !LTHIGH
5890      Yseg(12)=.433*(Ycoord(F,18)-Ycoord(F,17))+Ycoord(F,17)
5900      Xseg(13)=.433*(Xcoord(F,19)-Xcoord(F,18))+Xcoord(F,18) !L LEG
5910      Yseg(13)=.433*(Ycoord(F,19)-Ycoord(F,18))+Ycoord(F,18)
5920      Xseg(14)=.450*(Xcoord(F,21)-Xcoord(F,20))+Xcoord(F,20) !L FOOT
5930      Yseg(14)=.450*(Ycoord(F,21)-Ycoord(F,20))+Ycoord(F,20)
5940      IF Add$<>"Y" THEN RETURN
5950         Xseg(15)=Idist*(Xcoord(F,Ip2)-Xcoord(F,Ip1))+Xcoord(F,Ip1) ! IMPLEMENT
5960         Yseg(15)=Idist*(Ycoord(F,Ip2)-Ycoord(F,Ip1))+Ycoord(F,Ip1)
5970      RETURN
5980 ! -------------------------------------------------------------------------
```

```
5990 Cofgcalc:!    COFGCALC CALCULATES THE TOTAL BODY C OF G
6000       FOR S=1 TO Numsegs
6010          Xmoment(S)=Xseg(S)*Segwt(S)
6020          Ymoment(S)=Yseg(S)*Segwt(S)
6030          !
6040          Xcofg(F)=Xcofg(F)+Xmoment(S)
6050          Ycofg(F)=Ycofg(F)+Ymoment(S)
6060       NEXT S
6070       RETURN
6080 ! ----------------------------------------------------------------------
6090 Printout:!    PRINTS OUT THE DATA FOR EACH FRAME
6100       INPUT "Please enter a titile for your output",Title$
6110       PRINT Title$;LIN(2)
6120       PRINT "FRAME NUMBER ";F;":"
6130       PRINT "================";LIN(2)
6140       PRINT ,"      SEGMENT C OF G'S",,"      SEGMENT MOMENTS"
6150       PRINT ,"      ----------------",,"      ----------------"
6160       PRINT "SEGMENT","X COORD","Y COORD","WEIGHTING","X COORD","Y COORD"
6170       FOR S=1 TO Numsegs
6180          PRINT S,Xseg(S),Yseg(S),Segwt(S),Xmoment(S),Ymoment(S)
6190       NEXT S
6200       PRINT LIN(2)
6210       PRINT "TOTAL BODY C OF G  FOR FRAME #";F;"   XCOORD:";Xcofg(F);"    YCOORD:";Ycofg(F)
6220       PRINT "---------------------------------"
6230       RETURN
6240 ! ----------------------------------------------------------------------
6250 Summary: !
6260       PRINT LIN(2);"C OF G SUMMARY:"
6270       PRINT "==============="
6280       PRINT LIN(1)
6290       PRINT "FRAME","X COORD","Y COORD"
6300       PRINT "-----","-------","-------"
6310       FOR F=1 TO Totfrms
6320          PRINT F,Xcofg(F),Ycofg(F)
6330       NEXT F
6340       RETURN
6350 ! ----------------------------------------------------------------------
6360 Implement:!
6370       INPUT "Please enter the weight of the tool",Toolwt
6380       INPUT "Please enter the weight of the subject",Subwt
6390       Totwt=Subwt+Toolwt
6400       FOR C=1 TO 14
6410          Segwt(C)=Segwt(C)*Subwt/Totwt
6420       NEXT C
6430       Segwt(15)=Toolwt/Totwt
6440       Numsegs=15
6450       INPUT "Enter two points to be used to calc. the C of G of the implement (prox,dist)",Ip1,Ip2
6460       INPUT "Enter the distance of the C of G of the implement from the prox. pt (eg. 0.5)",Idist
6470       RETURN
6480 ! ***********************************************************************
```

```
10   ! File: SEGPLT                   Cartridge: GRAPHICS (1)
20   ! Date: Nov 9, 1983 (update)    Author: P.J.Thiessen
30   ! Desc: This program allows you to plot stick figures using a variety
40   ! of formats, different line types and locations etc.  You can choose any
50   ! sequence of points or frames, so that it is possible to plot specific
60   ! body segments rather than the whole figure.  ** NEW ** a new way of
70   ! defining locations has been added (much easier). (Nov 9/83)
80   ! Keys: GRAPHICS,PLOT,STICK,SEGMENT
90   ! --------------------------------------------------------------------------
100  DIM Coord(80,30,2),Cofg(80,2),File$[6],Fseq$[160]
110  DIM Segpts(40),Frames(100),Seq$[160],Format$[160],Descrfilm$[160],Descr$(80)[60]
120  DIM Label$[180],Top$[30],Bot$[30],Mid$[30],Loc(100,6),Areas(100)
130  DIM Midx(100),Midy(100),Flab$(100)[30]
140  DIM Lscale(100,4),Gscale(4),Uscale(4),Lt(10),Lw(10)
150  INTEGER Option
160  Frz$=CHR$(27)&"l"
170  Unfrz$=CHR$(27)&"m"
180  Clr$=CHR$(27)&"E"
190  Cont=19
200  PRINTER IS 16
210  PRINT PAGE;TAB(25);"  SEGMENT PLOTTING PROGRAM  ";LIN(2)
220  PRINT "         This program allows you to plot stick figures using a variety"
230  PRINT "   of formats, different line types and locations etc.  You can choose any"
240  PRINT "   sequence of points or frames, so that it is possible to plot specific"
250  PRINT "   body segments rather than the whole figure.  ** NEW ** a new way of"
260  PRINT "   defining locations has been added (much easier). (Nov 9/83)"
270  Seq$="1,2,3,4,5,6,-1,5,7,8,9,10,-1,5,11,12,13,14,15,16,-1,11,17,18,19,20,21,-1"
280 Main: !
290  GOSUB Readin
300  GOSUB Transform
310  GOSUB Scale
320  GOSUB Defseg
330  GOSUB Deframes
340  GOSUB Getlocations
350  GOSUB Show
360  GOSUB Plotseg
370  Lb$=""
380  INPUT "Do you want to label the plot [Y/N]",Lb$
390  IF Lb$="Y" THEN GOSUB Label
400  IF Lb$="" THEN BEEP
410  IF Lb$="" THEN GOTO 380
420  INPUT "Do you want to plot a new sequence [Y/N]",New$
430  IF New$()"Y" THEN GOTO 470
440      INPUT "Do you want to use the same data or use a new set of data [S/N]",Data$
450      IF Data$="N" THEN GOTO 290
460      GOTO 320
470  DISP "Program SEGPLT ended."
480  END
490 ! ------------------------------------------------------------------------
500 Defseg:PRINT PAGE;" SEGMENT DEFINITION ";LIN(1)
```

```
510       PRINT "   Please define the segment to be plotted by entering the order of the points"
520       PRINT "to be plotted.  Note that -1 means 'lift the pen off the paper'.";LIN(2);CHR$(27)&"l";PAGE;
530       PRINT "Example:  The following is a sequence of numbers defining a plotting order:";LIN(1)
540       PRINT "                                    5,6,-1,5,7,8,-1";LIN(1)
550       PRINT "This sequence would be interpreted as follows; 'Plot from point 5 to point 6."
560       PRINT "Lift the pen up.  Plot from point 5 to point 7, to point 8.  Lift the pen.'"
570       PRINT "This same sequence would be plotted for each frame.  Note that if the pen is"
580       PRINT "not lifted at the end of each frame the last point of the previous frame would"
590       PRINT "be joined to the first point of the next frame (ie 8 to 5 above).  For this"
600       PRINT "reason -1 is usually the last number, unless you want to join frames."
610       EDIT "Please enter the sequence of points ( -1 means 'Lift pen off paper')",Seq$
620       IF Seq$="" THEN Seq$="1,2,3,4,5,6,-1,5,7,8,9,10,-1,5,11,12,13,14,15,16,-1,11,17,18,19,20,21,-1"
630       CALL Getsequence(Seq$,Segpts(*),Numseg)
640       IF Segpts(Numseg)=-1 THEN GOTO 700
650           BEEP
660           INPUT "NOTE: Do you want the pen lifted after every frame [Y/N]",Lp$
670           IF Lp$="N" THEN GOTO 700
680               Numseg=Numseg+1
690               Segpts(Numseg)=-1
700       PRINT PAGE;"Number of points: ";Numseg;"";LIN(1)
710       PRINT "Plotting order:";LIN(1)
720       FOR I=1 TO Numseg
730           IF Segpts(I)>0 THEN PRINT "(";VAL$(I);")";Segpts(I),
740           IF Segpts(I)<0 THEN PRINT "(";VAL$(I);") PEN UP",
750       NEXT I
760       PRINT CHR$(27)&"m"
770       DISP "Please press CONTINUE to move on, or any other key to RE-DO ...."
780       IF READBIN(0)+256<>Cont THEN GOTO Defseg
790       RETURN
800 Deframes: PRINT Clr$;" FRAME DEFINITION ";LIN(1)
810       PRINT "   Please specify the frames you want to have plotted using one of the options"
820       PRINT "shown below.";LIN(2);Frz$;PAGE;
830       PRINT " I ndividual: You specify the individual frames that you want plotted in the"
840       PRINT "              order that you want them plotted such as 1,5,4,3,7,8.";LIN(1)
850       PRINT " S equence:   You specify the first frame to be plotted, the last frame, and"
860       PRINT "              the frame increment.  For example, 1,10,2 would have frames"
870       PRINT "              1,3,5,7,9 plotted. (Note: F=first frame, L=last frame)";LIN(1)
880       PRINT " A ll:        All the frames are to be plotted in ascending order."
890       INPUT "Please enter one of the options listed above",Frm$
900       Frm=POS("ISA",Frm$)
910       IF Frm=0 THEN GOTO 890
920       ON Frm GOSUB Indiv,Seq,All
930       GOSUB Checkframes
940       GOSUB Prtframes
950       DISP "Please press CONTINUE to move on, or any other key to RE-DO ...."
960       IF READBIN(0)+256<>Cont THEN GOTO Deframes
970       GOSUB Framelabels
980       PRINT Unfrz$;
990       RETURN
1000 All:Lastframe=Numfrms
```

```
1010     FOR I=1 TO Numfrms
1020         Frames(I)=I
1030     NEXT I
1040     RETURN
1050 Seq:First$="F"
1060     Last$="L"
1070     Step=1
1080     ON ERROR GOTO 1100
1090     DISP "Please enter the first frame, last frame, and step  [ N =";Numfrms;"]";
1100     INPUT "",First$,Last$,Step
1110     IF (First$="F") OR (First$="f") THEN First=1
1120     IF (Last$="L") OR (Last$="l") THEN Last=Numfrms
1130     IF NOT ((First$="F") OR (First$="f")) THEN First=VAL(First$)
1140     IF NOT ((Last$="L") OR (Last$="l")) THEN Last=VAL(Last$)
1150     OFF ERROR
1160     I=0
1170     FOR F=First TO Last STEP Step
1180         I=I+1
1190         Frames(I)=F
1200     NEXT F
1210     Lastframe=I
1220     RETURN
1230 Indiv:EDIT "Enter the frames you want plotted [eg. 1,15,2,24,etc.]",Fseq$
1240     First=1
1250     Step=1
1260     CALL Getsequence(Fseq$,Frames(*),Lastframe)
1270     RETURN
1280 Checkframes:Framerror=0
1290     FOR I=1 TO Lastframe
1300         IF NOT ((Frames(I)<1) OR (Frames(I)>Numfrms)) THEN GOTO 1350
1310             BEEP
1320             DISP " ERROR  -- ";Frames(I);"is an invalid frame number"
1330             Framerror=1
1340             WAIT 1000
1350     NEXT I
1360     RETURN
1370 Prtframes:PRINT PAGE;"Frames:";LIN(1)
1380     FOR I=1 TO Lastframe
1390         PRINT "(";VAL$(I);")";Frames(I),
1400     NEXT I
1410     RETURN
1420 Framelabels:INPUT "Do you want to plot any labels with the frames [Y/N]",Fl$
1430     REDIM Flab$(1:Lastframe)
1440     IF Fl$<>"Y" THEN GOTO Ltchanges
1450         INPUT "Please enter the labels in order (maximum of 30 characters)",Flab$(*)
1460         PRINT PAGE;"Frame Labels:";LIN(1)
1470         FOR F=1 TO Lastframe
1480             IF Flab$(F)<>"" THEN PRINT "(";VAL$(Frames(F));") ";Flab$(F),
1490         NEXT F
1500         PRINT LIN(1)
```

```
1510        INPUT "Please enter the CSIZE height,width, LORG and location (using LORG codes)",Csh,Csw,Lrg,Loc
1520        PRINT "CSIZE ";VAL$(Csh);",";VAL$(Csw);"   LORG";Lrg;"  LOC";Loc;LIN(1)
1530 Ltchanges:INPUT "Do you want to use different line types for different segments [Y/N]",Lt$
1540     IF Lt$<>"Y" THEN GOTO Cofgchar
1550        INPUT "Enter the number of changes",Numch
1560        PRINT "Line type changes:";Numch;"    (Note: Initial line type 1,4 [solid line])";LIN(1)
1570        PRINT "###","Joint","Line type","Width"
1580        FOR I=1 TO Numch
1590            DISP "Enter the joint number, line type and width for change ";I;
1600            INPUT "",Jnt(I),Lt(I),Lw(I)
1610            PRINT I,Jnt(I),Lt(I),Lw(I)
1620        NEXT I
1630        PRINT LIN(1);
1640 Cofgchar:INPUT "Do you want to plot the C of G's [Y/N]",Cg$
1650     IF Cg$="Y" THEN EDIT "Enter the label to be used to represent the C of G [eg * ]",Cgl$
1660     PRINT "C of G Character:  ";CHR$(34);Cgl$;CHR$(34)
1670     DISP "Please press CONTINUE to move on, or any other key to RE-DO ...."
1680     IF READBIN(0)+256<>Cont THEN GOTO Framelabels
1690     RETURN
1700 Getlocations:PRINT PAGE;TAB(30);" LOCATION DEFINITION ";LIN(1)
1710     PRINT "Option 1: Subdivide the plotter into areas";LIN(1)
1720     PRINT "           o  You specify the following:"
1730     PRINT "                 - the number of rows and colums of locations"
1740     PRINT "                 - the number of lines for the title and footnote"
1750     PRINT "                 - the number of lines of spacing between the rows
1760     PRINT "           o  The plotter is subdivided into areas as defined above, and the"
1770     PRINT "                 areas are displayed and numbered on the screen."
1780     PRINT "           o  You specify how many areas you want to use."
1790     PRINT "           o  You enter the area number(s) from the screen.";LIN(2)
1800     PRINT "Option 2: Define specific locations manually";LIN(1)
1810     PRINT "           o  You specify how many areas to be defined."
1820     PRINT "           o  You specify whether you want to digitize the areas or define "
1830     PRINT "                 them by entering coordinates in GDU's"
1840     PRINT "           o  You define the areas as specified above"
1850     INPUT "Please enter the option you want to use [1/2]",Loption
1860     IF (Loption<1) OR (Loption>2) THEN GOTO 1850
1870     ON Loption GOSUB Loption1,Loption2
1880     DISP "Please press CONTINUE to move on, or any other key to RE-DO ...."
1890     IF READBIN(0)+256<>Cont THEN GOTO Getlocations
1900     FOR L=1 TO Nloc
1910         Midx(L)=Loc(L,1)+(Loc(L,2)-Loc(L,1))/2
1920         Midy(L)=Loc(L,3)+(Loc(L,4)-Loc(L,3))/2
1930     NEXT L
1940     RETURN
1950 Loption1:INPUT " Option 1 : Enter the rows, columns, title lines, foot lines and spacing",Nr,Nc,Nt,Nf,S
p
1960     Plot=0
1970     INPUT " Option 1 :  Do you want the areas plotted [Y/N]",Plot$
1980     IF Plot$="Y" THEN Plot=1
1990     Print=1
```

```
2000      CALL Subdiv(Nr,Nc,Nt,Nf,Sp,Nloc,Loc(*),Print,Plot)
2010      INPUT "Are these subdivisions OK [Y/N]",Ok$
2020      IF Ok$="N" THEN GOTO Loption1
2030      INPUT "How many areas do you want to define",Nareas
2040      IF Nareas<=Nloc THEN GOTO 2090
2050         BEEP
2060         DISP "Sorry, you can only define a maximum of";Nloc;" areas using the above"
2070         WAIT 3000
2080         GOTO 2010
2090      REDIM Areas(1:Nareas)
2100      FOR A=1 TO Nareas
2110         Areas(A)=A
2120      NEXT A
2130      INPUT "Please enter the area numbers in the order you want them used (or CONT)",Areas(*)
2140      RETURN
2150 Show: PRINT PAGE;TAB(32);" SCALING OPTIONS ";LIN(1)
2160      PRINT "Option 1:  Local scaling"
2170      PRINT "           o Each area defined is scaled so that all the coordinates for it's"
2180      PRINT "                  corresponding frame will just fit inside.";LIN(1)
2190      PRINT "Option 2:  Global scaling"
2200      PRINT "           o  All the areas are given a scaling factor that would allow all the"
2210      PRINT "                frames defined to fit into each area"
2220      PRINT "           o  This maintains the same size picture for all frames, but does not"
2230      PRINT "                include frames that are not going to be plotted";LIN(1)
2240      PRINT "Option 3:  Universal scaling"
2250      PRINT "           o  All the areas are given a scaling factor that would allow any"
2260      PRINT "                frame to fit into the area(s) defined."
2270      PRINT "           o  This maintains the same size picture for all frames, including"
2280      PRINT "                frames that will not be plotted";LIN(1)
2290      PRINT "Option 4:  Manual scaling"
2300      PRINT "           o  You enter the scaling factors"
2310      INPUT "Please enter the scaling option [1,2,3,4]",Soption
2320      Soption=INT(Soption)
2330      IF (Soption<1 OR (Soption>4) THEN GOTO 2310
2340      IF Soption=2 THEN GOTO Globalscale
2350      IF Soption<4 THEN GOTO 2390
2360         FIXED 3
2370         DISP "Enter the Xmin,Xmax,Ymin,Ymax [Univ.=";VAL$(Gscale(1));",";VAL$(Gscale(2));",";VAL$(Gscale(
3));",";VAL$(Gcale(4));"]";
2380         INPUT "",Uscale(1),Uscale(2),Uscale(3),Uscale(4)
2390      RETURN
2400 Globalscale:Gscale(1)=Gscale(3)=9E99
2410      Gscale(2)=Gscale(4)=-9E99
2420      DISP "Calculating global scaling factors ...."
2430      FOR I=1 TO Lastframe
2440         F=Frames(I)
2450         Gscale(1)=MIN(Gscale(1),Lscale(F,1))
2460         Gscale(2)=MAX(Gscale(2),Lscale(F,2))
2470         Gscale(3)=MIN(Gscale(3),Lscale(F,3))
2480         Gscale(4)=MAX(Gscale(4),Lscale(F,4))
```

```
2490    NEXT I
2500    RETURN
2510 Plotseg:INPUT "Do you want to pause between each frame [Y/N]",Pas$
2520    DISP "Ready to plot -- just press 'CONTINUE'"
2530    PAUSE
2540    PLOTTER IS "9872A"
2550    FOR I=1 TO Lastframe
2560       F=Frames(I)
2570       LOCATE Loc(Areas(I),1),Loc(Areas(I),2),Loc(Areas(I),3),Loc(Areas(I),4)
2580       IF Soption=1 THEN SHOW Lscale(F,1),Lscale(F,2),Lscale(F,3),Lscale(F,4)
2590       IF Soption=2 THEN SHOW Gscale(1),Gscale(2),Gscale(3),Gscale(4)
2600       IF Soption=3 THEN SHOW Uscale(1),Uscale(2),Uscale(3),Uscale(4)
2610       DISP "Ready to plot frame ";F;""
2620       IF Pas$="Y" THEN PAUSE
2630       DISP "Plotting frame ";F;""
2640       J=1
2650       LINE TYPE 1,4
2660       FOR S=1 TO Numseg
2670          IF Segpts(S)=-1 THEN PENUP
2680          IF Segpts(S)=-1 THEN GOTO 2730
2690          IF Segpts(S)()Jnt(J) THEN GOTO 2720
2700             LINE TYPE Lt(J),Lw(J)
2710             J=J+1
2720          PLOT Coord(F,Segpts(S),1),Coord(F,Segpts(S),2)
2730       NEXT S
2740       IF Cg$()"Y" THEN GOTO 2840
2750          DISP "Ready to plot the C of G in frame ";F;""
2760          IF Pas$="Y" THEN PAUSE
2770          DISP "Plotting C of G in frame ";F;""
2780          LINE TYPE 1,4
2790          CSIZE 2.2
2800          LORG 5
2810          IF Rel$()"Y" THEN MOVE Cofg(F,1),Cofg(F,2)
2820          IF Rel$="Y" THEN MOVE 0,Cofg(F,2)
2830          LABEL Cgl$
2840       IF Fl$="Y" THEN GOSUB Plotlabel
2850    NEXT I
2860    LINE TYPE 1,4
2870    PENUP
2880    DISP
2890    RETURN
2900 Plotlabel:DISP "Labelling frame ";F;""
2910    RESTORE Loc_org
2920    SETGU
2930    FOR L=1 TO Loc
2940       READ X1,Y1
2950    NEXT L
2960    MOVE Loc(Areas(I),X1),Loc(Areas(I),Y1)
2970    LINE TYPE 1,4
2980    LORG Lrg
```

```
2990     CSIZE Csh,Csw
3000     LABEL Flab$(I)
3010     SETUU
3020     RETURN
3030     !        LL  ML  UL  LM  MM  UM  LR  MR  UR  (ie. Lower Left,Mid Right)
3040 Loc_org:DATA 1,3,1,6,1,4,5,3,5,6,5,4,2,3,2,6,2,4
3050 Label:Csize=3.3
3060     Width=.6
3070     Lorg=4
3080     SETGU
3090     Labx=Laby=9E99
3100     INPUT "Please enter the coordinates for the label [in GDU's]",Labx,Laby
3110     IF Labx=9E99 THEN RETURN
3120     MOVE Labx,Laby
3130     INPUT "Is this position acceptable [Y/N]",Accept$
3140     IF Accept$="N" THEN GOTO 3100
3150     Vertical=0
3160     INPUT "Enter the CSIZE, WIDTH, and LORG [Note: LORG 10 for vertical plot]",Csize,Width,Lorg
3170     IF Lorg=10 THEN Vertical=1
3180     IF Lorg=10 THEN Lorg=2
3190     CSIZE Csize,Width
3200     LORG Lorg
3210     IF Vertical THEN DISP "(Vertical plot requested) -- ";
3220     LINPUT "Please enter the label",Label$
3230     IF NOT Vertical THEN LABEL Label$;CHR$(128)
3240     IF NOT Vertical THEN GOTO 3090
3250         MOVE Labx,Laby+LEN(Label$)/2*Csize
3260         FOR C=1 TO LEN(Label$)
3270             LABEL Label$[C;1]
3280         NEXT C
3290         LABEL CHR$(128)
3300     GOTO 3080
3310 Readin:INPUT "Please enter the name of the data file that holds the coordinates",File$
3320     INPUT "Please enter the protect code of the file (if necessary)",P$
3330     DISP " Please insert the data cartridge  -- then press CONTINUE"
3340     PAUSE
3350     ASSIGN #1 TO File$,Rerr,P$
3360     IF NOT Rerr THEN GOTO 3410
3370         BEEP
3380         DISP " ERROR  -- ";File$;" cannot be located, or incorrect protect code"
3390         WAIT 2000
3400         GOTO Readin
3410     DISP "Reading in file ";File$;""
3420     READ #1;Format$,Descrfilm$,Numfrms,Numpts,Cfact,Time
3430     PRINT PAGE;"File: ";File$
3440     PRINT "Desc: ";Descrfilm$
3450     PRINT "Frames:";Numfrms;"Points:";Numpts;
3460     FIXED 8
3470     PRINT "Cfact:";Cfact;"Time:";Time;LIN(1)
3480     STANDARD
```

```
3490     REDIM Coord(1:Numfrms,1:Numpts,1:2),Cofg(1:Numfrms,1:2),Descr$(1:Numfrms)
3500     READ #1;Coord(*)
3510     READ #1;Cofg(*)
3520     READ #1;Descr$(*)
3530     PRINT "Frame Descriptions:"
3540     FOR F=1 TO Numfrms
3550         IF Descr$(F)<>"" THEN PRINT F,Descr$(F)
3560     NEXT F
3570     DISP "Please press CONTINUE"
3580     PAUSE
3590     RETURN
3600 Transform:!
3610     PRINT PAGE;" TRANSFORMATION OPTIONS ";LIN(1)
3620     PRINT "   Please specify the type of transformation you want performed on the coord-"
3630     PRINT "inates from the list below, or enter E to exit.";LIN(2)
3640     PRINT " F lip     -- Flip the coordinates about the X-axis to compensate for"
3650     PRINT "              projecting through the digitizer (mirror image)";LIN(1)
3660     PRINT " R elative -- convert the X-coordinate to their values relative to the "
3670     PRINT "              total body C of G";LIN(1)
3680     PRINT " C onvert  -- convert the coordinates to real distances using the scaling "
3690     PRINT "              factor";LIN(1)
3700     PRINT " E xit     -- exit this section of the program"
3710     INPUT "Transformations:  F lip,  R elative,  C onvert,  E xit",Tr$
3720     IF Tr$="F" THEN GOSUB Flip
3730     IF Tr$="R" THEN GOSUB Relative
3740     IF Tr$="C" THEN GOSUB Convert
3750     IF Tr$="E" THEN RETURN
3760     GOTO 3710
3770 Flip: DISP " F lip ...."
3780     FOR F=1 TO Numfrms
3790         FOR P=1 TO Numpts
3800             Coord(F,P,1)=17400-Coord(F,P,1)
3810         NEXT P
3820         Cofg(F,1)=17400-Cofg(F,1)
3830     NEXT F
3840     RETURN
3850 Relative:DISP " R elative ...."
3860     FOR F=1 TO Numfrms
3870         FOR P=1 TO Numpts
3880             Coord(F,P,1)=Coord(F,P,1)-Cofg(F,1)
3890         NEXT P
3900     NEXT F
3910     RETURN
3920 Convert:DISP " C onvert ...."
3930     MAT Coord=Coord*(Cfact)
3940     MAT Cofg=Cofg*(Cfact)
3950     RETURN
3960 Scale:PRINT PAGE;
3970     DISP "Calculating scaling factors ...."
3980     Uscale(1)=Uscale(3)=9E99
```

```
3990     Uscale(2)=Uscale(4)=-9E99
4000     FOR F=1 TO Numfrms
4010         Lscale(F,1)=Lscale(F,3)=9E99
4020         Lscale(F,2)=Lscale(F,4)=-9E99
4030         FOR P=1 TO Numpts
4040             Lscale(F,1)=MIN(Coord(F,P,1),Lscale(F,1))
4050             Lscale(F,2)=MAX(Coord(F,P,1),Lscale(F,2))
4060             Lscale(F,3)=MIN(Coord(F,P,2),Lscale(F,3))
4070             Lscale(F,4)=MAX(Coord(F,P,2),Lscale(F,4))
4080         NEXT P
4090         Uscale(1)=MIN(Uscale(1),Lscale(F,1))
4100         Uscale(2)=MAX(Uscale(2),Lscale(F,2))
4110         Uscale(3)=MIN(Uscale(3),Lscale(F,3))
4120         Uscale(4)=MAX(Uscale(4),Lscale(F,4))
4130     NEXT F
4140     DISP
4150     RETURN
4160 ! -----------------------------------------------------------------------
4170 Getsequence: SUB Getsequence(Seq$,Array(*),N)
4180  Seq$=TRIM$(Seq$)
4190  Count=1
4200  ON ERROR GOTO Seqerror
4210  FOR C=1 TO LEN(Seq$)
4220      IF Seq$[C;1]="," THEN GOTO 4270
4230      IF POS(Seq$[C],",") THEN Array(Count)=VAL(Seq$[C;POS(Seq$[C],",")])
4240      IF NOT POS(Seq$[C],",") THEN Array(Count)=VAL(Seq$[C])
4250      C=C+LEN(VAL$(Array(Count)))-1
4260      Count=Count+1
4270  NEXT C
4280  N=Count-1
4290  OFF ERROR
4300  SUBEND
4310 Seqerror: !
4320       BEEP
4330       DISP "ERROR in Subprogram Getsequence -- ";ERRM$
4340       PAUSE
4350       GOTO 4300
4360 ! -----------------------------------------------------------------------
4370 Subdiv:SUB Subdiv(Nr,Nc,Nt,Nb,Sp,Nloc,Loc(*),Print,Plot)
4380 Nloc=Nr*Nc
4390 Gdu_h=(100-5*(Nr-1)*Sp-5*Nt-5*Nb)/Nr
4400 Gdu_w=138.888888888/Nc
4410 Top=100-5*Nt
4420 A=1
4430 FOR R=1 TO Nr
4440     Bot=Top-Gdu_h
4450     Midy=Bot+(Top-Bot)/2
4460     FOR C=1 TO Nc
4470         Loc(A,1)=(C-1)*Gdu_w
4480         Loc(A,2)=C*Gdu_w
```

```
4490          Loc(A,3)=Bot
4500          Loc(A,4)=Top
4510          Loc(A,5)=Loc(A,1)+(Loc(A,2)-Loc(A,1))/2
4520          Loc(A,6)=Midy
4530          A=A+1
4540       NEXT C
4550       Top=Top-Gdu_h-5*Sp
4560 NEXT R
4570 W=INT(60/Nc)
4580 H=INT((19-(Nr-1)*Sp-Nt-Nb)/Nr)
4590 IF Print THEN GOSUB Print
4600 IF Plot THEN GOSUB Plot
4610 SUBEND
4620 Print:PRINTER IS 16
4630      PRINT CHR$(27);"E";
4640      PRINT " ";SPA(Nc*W-1);""
4650      FOR L=1 TO Nt
4660          IF L<Nt THEN PRINT CHR$(124);RPT$(" ",W*Nc-1);CHR$(124)
4670      NEXT L
4680      IF Nt THEN PRINT CHR$(124);"";SPA(Nc*W-1);"";CHR$(124)
4690      FOR R=1 TO Nr
4700          FOR I=1 TO H-1
4710              PRINT CHR$(124);RPT$(" ",W-1);RPT$(CHR$(124)&RPT$(" ",W-1),Nc-1);CHR$(124)
4720          NEXT I
4730          IF R=Nr THEN GOTO 4790
4740              PRINT CHR$(124);"";RPT$(" ",W-1);RPT$(CHR$(124)&RPT$(" ",W-1),Nc-1);"";CHR$(124)
4750              FOR I=1 TO Sp-1
4760                  PRINT CHR$(124);RPT$(" ",W*Nc-1);CHR$(124)
4770              NEXT I
4780              IF Sp THEN PRINT CHR$(124);"";SPA(Nc*W-1);"";CHR$(124)
4790      NEXT R
4800      PRINT CHR$(124);"";RPT$(" ",W-1);RPT$(CHR$(124)&RPT$(" ",W-1),Nc-1);"";CHR$(124)
4810      FOR L=1 TO Nb
4820          IF L<Nb THEN PRINT CHR$(124);RPT$(" ",W*Nc-1);CHR$(124)
4830      NEXT L
4840      IF Nb THEN PRINT CHR$(124);"";SPA(Nc*W-1);"";CHR$(124)
4850      Hw=W/2
4860      A=1
4870      Row=PROUND(Nt+H/2,0)
4880      FOR R=1 TO Nr
4890          FOR C=1 TO Nc
4900              PRINT USING "+,K";CHR$(27)&"&a"&VAL$(Row)&"r"&VAL$(INT((C-1)*W+W/2))&"C"&VAL$(A)
4910              A=A+1
4920          NEXT C
4930          Row=Row+H+Sp
4940      NEXT R
4950      RETURN
4960 Plot:PLOTTER IS "9872A"
4970      FRAME
4980      LORG 5
```

```
4990    FOR L=1 TO Nloc
5000        LOCATE Loc(L,1),Loc(L,2),Loc(L,3),Loc(L,4)
5010        FRAME
5020    NEXT L
5030    PLOTTER IS "9872A"
5040    RETURN
```

```
3570 End:!
3580 ! File: Autgrf                  Cartridge: GRAPHICS (1)
3590 ! Date: Fall/83 (Update)        Author: P.J. Thiessen
3600 ! Desc: This subprogram graphs a set of data points automatically. X and
3610 ! Y two dimensional arrays are passed by the main program.  The subprog.
3620 ! can be ordered to choose scaling factors for the data. A facility to plot
3630 ! stick figures above the graph is also provided (see Graphtrace, below).
3640 ! Note: Option=0 -- Auto scale      Option=1 -- Manual scale
3650 !       Option=2 -- Auto scale, pause between operations (for pen change)
3660 !       Option=3 -- Manual scale, pause between operations (for pen change)
3670 ! Keys: GRAPHICS,PLOT,CURVE,AUTOMATIC,SUB
3680 ! ------------------------------------------------------------------------
3690 Autograph:SUB Autograph(N,Nv,X(*),Y(*),Var(*),Scale(*),Loc(*),Xaxis$,Yaxis$,Legend$(*),Title$,Foot$,Optio
n)
3700 PLOTTER IS 7,5,"9872A"
3710 PRINTER IS 16
3720 DEG
3730 GOSUB Getmaxmins
3740 GOSUB Scale
3750 GOSUB Plotdata
3760 GOSUB Axislabel
3770 GOSUB Legend
3780 GOSUB Title_foot
3790 SETGU
3800 MOVE 138.8888,100  ! Move pen to top right
3810 SUBEND
3820 Out:DISP " Autograph Subprogram completed "
3830 WAIT 1000
3840 SUBEND
3850 Getmaxmins:Xmax=Ymax=-9E99
3860       Xmin=Ymin=9E99
3870       FOR I=1 TO N
3880           FOR J=1 TO Nv
3890               Xmax=MAX(Xmax,X(I,Var(J)))
3900               Ymax=MAX(Ymax,Y(I,Var(J)))
3910               Xmin=MIN(Xmin,X(I,Var(J)))
3920               Ymin=MIN(Ymin,Y(I,Var(J)))
3930           NEXT J
3940       NEXT I
3950       RETURN
3960 Scale:IF NOT SUM(Loc)=0 THEN GOTO 4000
3970           Loc(1)=Loc(3)=20
3980           Loc(2)=110
3990           Loc(4)=90
4000       LOCATE Loc(1),Loc(2),Loc(3),Loc(4)
4010       IF (Option<>1) AND (Option<>3) THEN GOTO 4140
4020           BEEP
4030           DISP "Enter Xmin,Xmax,Xmajor,Xminor (";Xmin;",";Xmax;")";
4040           INPUT "",Xm,Xx,Xminor,Xmajor
4050           Xminor=(Xx-Xm)/(Xmajor*Xminor)
```

```
4060            Xstep=Xminor*Xmajor
4070            Xformat$=FNFormat$(Xm,Xx,Xstep)
4080            DISP "Enter Ymin,Ymax,Ymajor,Yminor (";Ymin;",";Ymax;")";
4090            INPUT "",Ym,Yx,Yminor,Ymajor
4100            Yminor=(Yx-Ym)/(Ymajor*Yminor)
4110            Ystep=Yminor*Ymajor
4120            Yformat$=FNFormat$(Ym,Yx,Ystep)
4130        GOTO 4160
4140            CALL Minmax(Xmin,Xmax,Xm,Xx,Xstep,Xmajor,Xminor,Xformat$)
4150            CALL Minmax(Ymin,Ymax,Ym,Yx,Ystep,Ymajor,Yminor,Yformat$)
4160        SCALE Xm,Xx,Ym,Yx
4170        DISP "X-Scale:";Xm;Xx;Xstep;"(";Xformat$;")","Y-Scale:";Ym;Yx;Ystep;"(";Yformat$;")"
4180        IF Option<2 THEN GOTO 4210
4190            DISP " Pen Change  -- Ready to plot Axes, press CONTINUE"
4200            PAUSE
4210        GOSUB Plotter_ok
4220        DISP "X-Scale:";Xm;Xx;Xstep;"(";Xformat$;")","Y-Scale:";Ym;Yx;Ystep;"(";Yformat$;")"
4230        Majticwidth=1.5
4240        AXES Xminor,Yminor,Xm,Ym,Xmajor,Ymajor,Majticwidth
4250        Scale(1)=Xm
4260        Scale(2)=Xx
4270        Scale(3)=Ym
4280        Scale(4)=Yx
4290        RETURN
4300 Plotdata:!
4310        RESTORE Linetypes
4320        FOR J=1 TO Nv
4330            V=Var(J)
4340            READ Lt,Ll
4350            LINE TYPE Lt,Ll
4360            IF Option<2 THEN GOTO 4400
4370                BEEP
4380                DISP " Pen Change  -- Ready to plot data set";V;"(LINE TYPE ";VAL$(Lt);",";VAL$(Ll);")"
4390                PAUSE
4400            FOR I=1 TO N
4410                PLOT X(I,V),Y(I,V)
4420            NEXT I
4430            PENUP
4440            IF NOT J MOD 10 THEN RESTORE Linetypes
4450        NEXT J
4460        RETURN
4470 Linetypes:DATA 1,4,4,1,3,.5,6,3,7,4,8,4,5,2,9,4,10,4,2,1
4480 Axislabel:IF Option<2 THEN GOTO 4520
4490            BEEP
4500            DISP " Pen Change  -- Ready to label the X axis"
4510            PAUSE
4520        LINE TYPE 1,4
4530        CSIZE 2
4540        LORG 6
4550        FOR L=Xm TO Xx STEP Xstep
```

```
4560        MOVE L,Ym
4570        SETGU
4580        CURSOR X,Y
4590        MOVE X,Y-1
4600        LABEL USING Xformat$;L
4610        SETUU
4620     NEXT L
4630     SETGU
4640     Xin=3*2.25  ! 3 times the character size of the axis labels
4650     MOVE Loc(1)+(Loc(2)-Loc(1))/2,Loc(3)-Xin
4660     CSIZE 3
4670     LABEL Xaxis$
4680     SETUU
4690     IF Option<2 THEN GOTO 4730
4700        BEEP
4710        DISP " Pen Change  -- Ready to label the Y axis"
4720        PAUSE
4730     LORG 8
4740     CSIZE 2
4750     FOR L=Ym TO Yx STEP Ystep
4760        MOVE Xm,L
4770        SETGU
4780        CURSOR X,Y
4790        MOVE X-1,Y
4800        LABEL USING Yformat$;L
4810        SETUU
4820     NEXT L
4830     SETGU
4840     LORG 4
4850     LDIR 90
4860     Yin=LEN(Format$)*.6+10
4870     MOVE Loc(1)-Yin,Loc(3)+(Loc(4)-Loc(3))/2
4880     CSIZE 3
4890     LABEL Yaxis$
4900     SETUU
4910     RETURN
4920 Legend:IF Option<2 THEN GOTO 4960
4930        BEEP
4940        DISP " Pen Change  -- Ready to plot the Legend"
4950        PAUSE
4960     Lx=0
4970     FOR J=1 TO Nv
4980        Lx=MAX(Lx,LEN(Legend$(Var(J))))
4990     NEXT J
5000     IF Lx=0 THEN RETURN
5010     IF Lx>10 THEN Lx=10
5020     Lwidth=.4*(10/Lx)
5030     IF Lwidth>.6 THEN Lwidth=.6
5040     SETGU
5050     MOVE 126,80
```

```
5060       CSIZE 3,.6
5070       LORG 4
5080       LDIR 0
5090       LABEL "LEGEND"
5100       MOVE 120.8,79.4    ! Underline
5110       DRAW 131.1,79.4
5120       LORG 1
5130       RESTORE Linetypes
5140       Mult=5
5150       IF Nv<6 THEN Mult=10
5160       FOR J=1 TO Nv
5170           V=Var(J)
5180           Y=80-Mult-(J-1)*Mult
5190           MOVE 115,Y
5200           CSIZE 3,Lwidth
5210           IF Option<2 THEN GOTO 5250
5220               BEEP
5230               DISP " Pen Change  -- Ready to label ";Legend$(V);""
5240               PAUSE
5250           IF LEN(Legend$(V))<10 THEN LABEL Legend$(V)
5260           IF NOT (LEN(Legend$(V))<10) THEN LABEL Legend$(V)[1;10]
5270           MOVE 128.2,Y
5280           CSIZE 3,.375
5290           LABEL "[       ]"
5300           MOVE 129.5,Y+.75
5310           READ Lt,Ll
5320           IF Ll=4 THEN Ll=3
5330           LINE TYPE Lt,Ll
5340           DRAW 135.5,Y+.75
5350           PENUP
5360           LINE TYPE 1,4
5370       NEXT J
5380       PENUP
5390       RETURN
5400 Title_foot:CSIZE 3.3,.6
5410       SETGU
5420       LDIR 0
5430       LORG 6
5440       IF Foot$="" THEN GOTO 5510
5450       MOVE Loc(1)+(Loc(2)-Loc(1))/2,Loc(3)-(Loc(4)-Loc(3))*.2
5460       IF Option<2 THEN GOTO 5500
5470           BEEP
5480           DISP " Pen Change  -- Ready to plot footnote ";Foot$;""
5490           PAUSE
5500       LABEL Foot$
5510       LORG 4
5520       IF Title$="" THEN GOTO 5590
5530       MOVE Loc(1)+(Loc(2)-Loc(1))/2,Loc(4)+(Loc(4)-Loc(3))*.05
5540       IF Option<2 THEN GOTO 5580
5550           BEEP
```

```
5560         DISP " Pen Change  -- Ready to plot title ";Title$;""
5570         PAUSE
5580       LABEL Title$
5590       RETURN
5600 Plotter_ok:STATUS 7,5;Status
5610       IF NOT BIT(Status,7) THEN RETURN
5620       BEEP
5630       DISP "Please turn PLOTTER chart load button OFF"
5640       STATUS 7,5;Status
5650       IF BIT(Status,7) THEN GOTO 5620
5660       DISP
5670       RETURN
5680 ! File: Minmax                 Cartridge: GRAPHICS
5690 ! Date: May, 1983              Author: P.J.Thiessen
5700 ! Desc: This subprogram determines the parameters necessary for plotting
5710 ! an axis.  It determines the min,max,step, and minor tic values as well
5720 ! as the format needed for the labels.  Implementation of the subprogram
5730 ! for graphing could allow more automatic plotting and labelling of the
5740 ! axes as well as scaling the area defined by a LOCATE statement.
5750 ! Keys: MIN,MAX,AXIS,AXES,GRAPHICS,PLOT,LABEL,SCALE
5760 ! --------------------------------------------------------------------
5770 Minmax:SUB Minmax(Oldmin,Oldmax,Newmin,Newmax,Step,Major,Minor,Format$)
5780 DIM F$[15]
5790 Rs:Okay=0
5800 IF Oldmin(Oldmax THEN 5840
5810     Hold=Oldmin
5820     Oldmin=Oldmax
5830     Oldmax=Hold
5840 GOSUB Integer
5850 GOSUB Getmaxmin
5860 GOSUB Convertback
5870 GOSUB Ticspacing
5880 Format$=FNFormat$(Newmin,Newmax,Step)
5890 SUBEND
5900 Integer:!
5910       Oldiff=Oldmax-Oldmin
5920       P1=FNPower(Oldmax)
5930       P2=FNPower(Oldmin)
5940       P3=FNPower(Olddiff)
5950       Power=MAX(P1,P2,P3)
5960       Min=Oldmin*10^(-(Power-1))
5970       Max=Oldmax*10^(-(Power-1))
5980       IF (ABS(Min))=10) OR (ABS(Max))=10) THEN GOTO 6010
5990           Power=Power-1
6000           GOTO 5960
6010       Om=Min
6020       Om=Mi
6030       Ox=Max
6040       Min=PROUND(Min,0)
6050       IF Min(=Om THEN GOTO 6080
```

```
6060            Min=Om-1
6070            GOTO 6040
6080        Max=PROUND(Max,0)
6090        IF Max>=Ox THEN GOTO 6120
6100            Max=Ox+1
6110            GOTO 6080
6120        Diff=Max-Min
6130        Decmin=Min
6140        Decmax=Max
6150        RETURN
6160 Getmaxmin:RESTORE Nearest_div
6170        Oldecmin=Decmin
6180        Oldecmax=Decmax
6190 Top:   Decdiff=Decmax-Decmin
6200        GOSUB Getcommondiv
6210        GOTO 6260
6220        PRINT "Orig:";Oldmin;Oldmax
6230        PRINT "Min:";Decmin;"Max:";Decmax;"Diff";Decdiff
6240        PRINT "GCdec:";Gcdec;"GCD:";Gcd
6250        PRINT "-------------------------------------------"
6260        IF NOT (Gcd>1) THEN GOTO 6400
6270            Numdiv=Decdiff/Gcd
6280            IF (Numdiv<11) AND (Numdiv>2) AND (Gcd<>11) THEN GOTO 6380
6290            IF (Gcd<>Decdiff) AND (Gcd<>Decmin) AND (Gcd<>Decmax) THEN GOTO 6390
6300                IF Gcd>10 THEN GOTO 6330
6310                    Gcd=1
6320                GOTO 6270
6330                    Newgcd=FNGcd(0,Decdiff)
6340                    IF (Newgcd=Gcd) OR (Newgcd=0) THEN GOTO 6390
6350                    Gcd=Newgcd
6360                GOTO 6270
6370            GOTO 6390
6380                Okay=1
6390        IF Okay THEN RETURN
6400            IF Near<>Decdiff THEN GOTO 6440
6410                Power=Power-1
6420                GOSUB 5960    ! Get a new set of min,max's
6430                GOTO Getmaxmin
6440            READ Near
6450                Decmin=Oldecmin
6460                Decmax=Oldecmax
6470                GOSUB Minear
6480                GOSUB Maxnear
6490                Gcd=Near
6500                GOTO Top
6510        RETURN
6520 Nearest_div:DATA 2,5,10,20
6530 Getcommondiv:Gcd=Gdmin=Gdmax=0
6540        Gcdec=FNGcd(Decmin,Decmax)
6550        Gcd=FNGcd(Gcdec,Decdiff)
```

```
6560        RETURN
6570 Minear:IF NOT (Decmin MOD Near) THEN RETURN
6580        Decmin=Decmin-Decmin MOD Near
6590        RETURN
6600 Maxnear:IF NOT (Decmax MOD Near) THEN RETURN
6610        Decmax=Decmax+(Near-Decmax MOD Near)
6620        RETURN
6630 Convertback:!
6640        Newmin=Decmin*10^(Power-1)
6650        Newmax=Decmax*10^(Power-1)
6660        Step=Gcd*10^(Power-1)
6670        IF NOT Near THEN GOTO 6710
6680            IF Near=20 THEN Minortics=2
6690            IF Near<>20 THEN Minortics=5
6700        GOTO 6740
6710            Minortics=Gcd
6720            IF (Minortics=10) OR (Minortics=1) THEN Minortics=5
6730            IF Minortics>10 THEN Minortics=1
6740        RETURN
6750 Ticspacing:IF Near=0 THEN Near=1
6760        IF Numdiv>4 THEN GOTO 6800
6770            Numdiv=Numdiv*2
6780            Gcd=Gcd*2
6790            Step=Step/2
6800        Minor=(Newmax-Newmin)/(Numdiv*Gcd)
6810        Major=Gcd
6820        IF Major<10 THEN GOTO 6870
6830            Dd=FNGcd(Major,0)
6840            Major=Major/Dd
6850            Minor=Minor*Dd
6860            GOTO 6820
6870        IF Major>1 THEN GOTO 6900
6880            Major=Major*5
6890            Minor=Minor/5
6900        RETURN
6910 ! ------------------------------------------------------------------
6920 ! Function Power finds the power of a value as expressed in floating point
6930 ! notation.  (ie. 3.210987654E-04 would yield -4)
6940 ! ------------------------------------------------------------------
6950 Power:DEF FNPower(N)
6960 DIM N$[18]
6970 FLOAT 11                        ! Force floating point notation
6980 N$=VAL$(N)                      ! Use string version of number
6990 Power=VAL(N$[POS(N$,"E")+1])   ! Strip off the power value
7000 STANDARD
7010 RETURN Power
7020 ! ------------------------------------------------------------------
7030 ! FNGcd: Finds the greatest common divisor of two numbers unless one of
7040 ! them is zero.  For zero it tries to return a divisor between 1 and 10 for
7050 ! the non-zero number.
```

```
7060 ! ------------------------------------------------------------------------
7070 Gcd:DEF FNGcd(A,B)
7080 INTEGER G,R,Gprime,Rprime
7090 G=ABS(A)
7100 R=ABS(B)
7110 IF (G=0) OR (R=0) THEN GOTO Find_div
7120 IF R<=0 THEN RETURN G
7130     Gprime=G DIV R
7140     Rprime=INT(G-Gprime*R)
7150     G=R
7160     R=Rprime
7170 GOTO 7120
7180 Find_div:! Find a divisor between 1 and 10 for the non-zero value
7190 IF (R=0) AND (G<>0) THEN N=G        ! Choose the non zero value
7200 IF (G=0) AND (R<>0) THEN N=R        ! to work with.
7210 IF N=0 THEN RETURN 0                ! If both are zero return 0.
7220 IF NOT (N MOD 10) AND (N<>10) THEN Div=1   ! If N is divisible by ten
7230 IF Div THEN N=N/10                  ! Then use N/10 (ie. 120 = 12)
7240 IF NOT Div THEN Try=1
7250 Try=Try+1                           ! Start with 2
7260 IF NOT (Try>10) THEN 7290           ! Stop at 9
7270     IF Div THEN N=N*10              ! If you divided then return N*10
7280     RETURN N
7290 IF N MOD Try THEN 7250              ! Remainder?  If yes then try again.
7300 IF (N/Try>10) OR (N/Try<3) THEN GOTO 7250! No!  Is N a good value?
7310 IF Div THEN Try=Try*10              ! Yes! If you divided then return Try*10
7320 RETURN Try                          ! Return the divisor.
7330 ! ------------------------------------------------------------------------
7340 ! FNFormat: Given the min,max,and step of a data set this function returns
7350 ! a string that can be used to format the output.
7360 ! ------------------------------------------------------------------------
7370 Frmt:DEF FNFormat$(Min,Max,Step)
7380 Format$=""
7390 STANDARD
7400 S=P=D=F=0
7410 I$=VAL$(Min)
7420 GOSUB Count
7430 I$=VAL$(Min+Step)
7440 GOSUB Count
7450 I$=VAL$(Max)
7460 GOSUB Count
7470 IF S THEN Format$="M"
7480 IF D THEN Format$=Format$&RPT$("D",D-1)&"Z"
7490 IF F THEN Format$=Format$&"."&RPT$("D",F)
7500 RETURN Format$
7510 Count:! Count digits before and after decimal point & check for sign
7520       IF NOT POS(I$,"-") THEN GOTO 7550
7530          S=1
7540          I$=I$[2]
7550       P=POS(I$,".")
```

```
7560       IF NOT P THEN GOTO 7630
7570          IF P=1 THEN 7610
7580             D=MAX(D,POS(I$,".")-1)
7590             F=MAX(F,LEN(I$[POS(I$,".")+1]))
7600          GOTO 7620
7610             F=MAX(F,LEN(I$)-1)
7620       GOTO 7640
7630          D=MAX(D,LEN(I$))
7640       RETURN
7650 End:!
7660 ! SUB Graphtrace: Can be used to plot stick figures (tracings) above
7670 ! a predefined graph automatically.
7680 ! X(*),Y(*) -- XY-coordinates of the joint points
7690 ! T(*)      -- time reference for the x-axis
7700 ! S(*),L(*) -- SCALE and LOCATE arrays (dimension=4)
7710 ! Nf,F(*)   -- Number of frames to be plotted and the frame numbers (F(*))
7720 ! Manual    -- If Manual=1 then user defines the plotting order and line
7730 !              type changes
7740 ! NOTE that F(*) must be an INTEGER array.
7750 ! ---------------------------------------------------------------------
7760 Graphtrace:SUB Graphtrace(X(*),Y(*),T(*),S(*),L(*),Numfrms,Numpts,Nf,Manual,INTEGER F(*))
7770 SHORT Jnt(100),Lt(100),Ll(100)
7780 INTEGER Po(50)
7790 IF SUM(L)=0 THEN INPUT "Please enter the LOCATE parameters in order",L(1),L(2),L(3),L(4)
7800 IF SUM(S)=0 THEN INPUT "Please enter the SCALE parameters in order",S(1),S(2),S(3),S(4)
7810 LOCATE L(1),L(2),L(3),L(4)
7820 SCALE S(1),S(2),S(3),S(4)
7830 PRINTER IS 16
7840 GOSUB Initialize   ! Set up plotting order and default line type change
7850 IF Manual THEN GOSUB Manualsetup
7860 GOSUB Getinitialpos
7870 GOSUB Plotter_ok
7880 FOR C=1 TO Nf
7890     GOSUB Getmaxmin
7900     GOSUB Plotracing
7910     IF C<Nf THEN GOSUB Getnewpos
7920 NEXT C
7930 DISP " Tracing Subprogram completed "
7940 Out:SUBEND
7950 Initialize:RESTORE Plotord
7960       READ Nplot
7970       REDIM Po(1:Nplot)   ! Order for up to 30 points
7980       READ Po(*)
7990       Jnt(1)=22           ! Default line type change after 21 points
8000       Lt(1)=3             ! (all body coord) to dotted line.
8010       Ll(1)=.3
8020       RETURN
8030 Plotord:DATA 37
8040       DATA 1,2,3,4,5,6,-1,5,7,8,9,10,-1,5,11,12,13,14,15,16,-1
8050       DATA 11,17,18,19,20,21,-1,22,23,24,25,26,27,28,29,30
```

```
8060 Manualsetup:INPUT "Please enter the number of elements for the plottong order array",Nplot
8070        Jnt(1)=0
8080        REDIM Po(1:Nplot)
8090        INPUT "Please enter the plotting order",Po(*)
8100        INPUT "Please enter the number of LINE TYPE changes to be made",Nc
8110        FOR C=1 TO Nc
8120            DISP "Enter the joint number, line type and line length for change";C;
8130            INPUT "",Jnt(C),Lt(C),Ll(C)
8140        NEXT C
8150        IF Manual THEN GOTO 8160
8160        RETURN
8170 Getime:ON ERROR GOTO Onedim
8180        Tm=T(F(I),1)
8190        OFF ERROR
8200        RETURN
8210 Onedim:IF ERRN()16 THEN GOTO Errortrap
8220        Tm=T(F(I))
8230        OFF ERROR
8240        RETURN
8250 Errortrap:BEEP
8260        DISP ERRM$
8270        PAUSE
8280        GOTO Errortrap
8290 Getinitialpos:GOSUB Plotter_ok
8300        LOCATE L(1),L(2),L(3),L(4)
8310        SCALE S(1),S(2),S(3),S(4)
8320        I=1
8330        GOSUB Getime
8340        MOVE Tm,S(4)
8350        SETGU
8360        CURSOR Xc,A
8370        Ymin=92
8380        MOVE Xc,Ymin
8390        H=8
8400        W=(L(2)-L(1))/Nf
8410        Xmin=Xc-W/2
8420        Xmax=Xc+W/2
8430        Ymax=Ymin+H
8440        LOCATE Xmin,Xmax,Ymin,Ymax
8450        RETURN
8460 Getnewpos:LOCATE L(1),L(2),L(3),L(4)
8470        SCALE S(1),S(2),S(3),S(4)
8480        I=C+1
8490        GOSUB Getime
8500        MOVE Tm,S(4)
8510        SETGU
8520        CURSOR Xc,A
8530        Xmin=Xc-W/2
8540        Xmax=Xc+W/2
8550        LOCATE Xmin,Xmax,Ymin,Ymax
```

```
8560       RETURN
8570 Getmaxmin:Xsmax=Ysmax=-9E99
8580       Xsmin=Ysmin=9E99
8590       FOR P=1 TO Numpts
8600           IF X(F(C),P)>Xsmax THEN Xsmax=X(F(C),P)
8610           IF Y(F(C),P)>Ysmax THEN Ysmax=Y(F(C),P)
8620           IF X(F(C),P)<Xsmin THEN Xsmin=X(F(C),P)
8630           IF Y(F(C),P)<Ysmin THEN Ysmin=Y(F(C),P)
8640       NEXT P
8650       MOVE Xc,Ymin-.5
8660       DRAW Xc,Ymin-1
8670       CSIZE 1.75
8680       LORG 4
8690       LDIR PI
8700       LABEL "^"
8710       SETUU
8720       SHOW Xsmin,Xsmax,Ysmin,Ysmax
8730       RETURN
8740 Plotracing:DISP "Plotting frame ";CHR$(129);F(C);CHR$(128)
8750       LINE TYPE 1,4
8760       J=1
8770       FOR I=1 TO Nplot
8780           P=Po(I)
8790           IF P<>Jnt(J) THEN GOTO 8820
8800               LINE TYPE Lt(J),Ll(J)
8810               J=J+1
8820           IF P=-1 THEN GOTO 8860
8830           IF P>Numpts THEN GOTO 8870
8840               PLOT X(F(C),P),Y(F(C),P)
8850           GOTO 8870
8860               PENUP
8870       NEXT I
8880       PENUP
8890       LINE TYPE 1,4
8900       RETURN
8910 Order1:DATA 1,2,3,-1,2,4,5,-1
8920 Plotter_ok:STATUS 7,5;Status
8930       IF NOT BIT(Status,7) THEN RETURN
8940       BEEP
8950       DISP "Please turn PLOTTER chart load button off"
8960       STATUS 7,5;Status
8970       IF NOT BIT(Status,7) THEN GOTO 8990
8980       GOTO 8940
8990       DISP
9000       RETURN
```

```
2120 End:!
2130 ! File: Ptincl                    Cartridge: R.SHORE THESIS (1)
2140 ! Date: Dec, 1983                 Author: P.J.Thiessen
2150 ! Desc: This subprogram calculates the inclination of a segment given the
2160 ! two endpoints of the segment.  It keeps track of revolutions (ie angles
2170 ! greater than 360 deg.) provided the transition is from the 4th quadrant
2180 ! to the first quadrant.  Points are passed individually and Rev is passed
2190 ! back and forth.
2200 ! Keys: INCLINATION,INCLINE,ANGLE,SLOPE,SUB
2210 ! ---------------------------------------------------------------------
2220 Incline:SUB Ptincl(Xprox,Yprox,Xdistal,Ydistal,Incline(*),F,Numv,Rev,Previ)
2230 DEFAULT ON
2240 GOSUB Getincline
2250 GOSUB Adjustrevs
2260 SUBEND
2270 Getincline:Y=Ydistal-Yprox
2280       X=Xdistal-Xprox
2290       Incline=ATN(Y/X)+PI*(X<0)+2*PI*((X>=0) AND (Y<0))
2300       RETURN
2310 Adjustrevs:IF (Previ>3/2*PI) AND (Incline<PI) THEN Rev=Rev+1
2320       IF Previ AND (Previ<PI/2) AND (Incline>PI) THEN Rev=Rev-1
2330       Incline(F,Numv)=Incline+2*PI*Rev
2340       Previ=Incline
2350       RETURN
```

```
10 End:  !
20   ! File: Velaci                  Cartridge: DATA SMOOTHING
30   ! Date: 1980?                   Author: P.J.Thiessen
40   ! Desc: This subprogram calculates the first and second derivatives of an
50   ! array.  A first finite differences technique is used.  The array must be
60   ! two dimensional.  The velocity and acceleration arrays are also passed.
70   ! Keys: DIFFER,NUMANL,FINITE DIFFERENCES,1ST,SMOOTH,VELOCITY,ACCEL,SUB
80   ! ----------------------------------------------------------------------
90   SUB Velacc(S(*),V(*),A(*),N,V,Time)
100  !
110  ! Calculate Velocity:
120  !
130  V(1,V)=(S(2,V)-S(1,V))/Time
140  FOR C=2 TO N-1
150      V(C,V)=(S(C+1,V)-S(C-1,V))/(2*Time)
160  NEXT C
170  V(N,V)=(S(N,V)-S(N-1,V))/Time
180  !
190  ! Calculate Acceleration:
200  !
210  A(1,V)=(V(2,V)-V(1,V))/Time
220  FOR C=2 TO N-1
230      A(C,V)=(V(C+1,V)-V(C-1,V))/(2*Time)
240  NEXT C
250  A(N,V)=(V(N,V)-V(N-1,V))/Time
260  SUBEND
```

```
2720 End:!
2730 ! File: Fourie                  Cartridge: DATA SMOOTHING & GRAPHICS
2740 ! Date: March 16,1982 (update)  Authors: Wayne Brodland & P.J.Thiessen
2750 ! Desc:  This is the working version of the Fourier Transform data smooth-
2760 ! ing subprogram.  The program calculates the fourier transform of a data
2770 ! set up to a specified harmonic.  The N/2 th harmonic will return the
2780 ! original data set, any less will smooth the data.  Plotting of the new
2790 ! data set is also possible.  DEF FNFourier_N(N) is also supplied to
2800 ! return the number of working data points necessary for the transform.
2810 ! Keys: NUMANL,SMOOTH,FOURIER,TRANSFORM,SIN,COS,DIFFER,VEL,ACCEL,SUB
2820 ! ----------------------------------------------------------------------
2830 Fourier:SUB Fourier(X(*),Vel(*),Acc(*),N,Numv,Time,Cutoff,Option)
2840 DIM X0(N*2.5,2),X1(N*2.5,2)
2850 GOSUB Prepare
2860 GOSUB Transform
2870 GOSUB Cutoff
2880 GOSUB Fourier_t
2890 GOSUB Transform
2900 GOSUB Printinverse
2910 IF NOT Option THEN GOTO 3020
2920     INPUT "Do you want to plot the data sets [Y/N]",Pl$
2930     IF Pl$="Y" THEN GOSUB Plot
2940     INPUT "Please enter  S cratch (to return original data),  R esmooth or  A ccept",Accept$
2950     IF Accept$="A" THEN GOTO 3020
2960     IF Accept$="S" THEN GOTO 3030
2970     DISP "Please enter a cutoff (Currently ";Cutoff;", N =";Nw;")";
2980     INPUT Cutoff
2990     MAT X0=ZER
3000     MAT X1=ZER
3010 GOTO 2850
3020     GOSUB Return
3030 SUBEND
3040 Prepare:!
3050     Cutoff=INT(Cutoff)
3060     Nw=FNFourier_n(N)       ! Calculate a compatible number of data points
3070     REDIM X0(Nw,2),X1(Nw,2)
3080     Slope=(X(N,Numv)-X(1,Numv))/(N-1)
3090     Shift=X(1,Numv)-Slope
3100     FOR I=1 TO N                         ! Reduce data set to a periodic
3110         X0(I,0)=X(I,Numv)-(Slope*I+Shift)  ! curve using slope of data set
3120     NEXT I
3130     X0(0,0)=0
3140     FOR I=N+1 TO Nw
3150         X0(I,0)=0
3160     NEXT I
3170     Duration=Time*Nw
3180     Maxfreq=Nw/Duration
3190     Fstep=1/Duration
3200     IF Cutoff<=Nw/2 THEN GOTO 3240
3210         IF Option THEN BEEP
```

```
3220         IF Option THEN DISP "Cutoff out of valid range.  Will be reset to";Nw/2;""
3230         Cutoff=Nw/2
3240      STANDARD
3250      IF NOT Option THEN 3440
3260         PRINTER IS 16
3270         PRINT CHR$(27)&"m";PAGE;
3280         PRINT CHR$(129);TAB(29);"FAST FOURIER TRANSFORM";TAB(80);CHR$(128)
3290         PRINT "Original N:";N;TAB(20);
3300         FIXED 5
3310         PRINT "Slope";Slope;TAB(40);"Shift:";Shift
3320         STANDARD
3330         PRINT "Working  N:";Nw;TAB(20);"Max Harmonic:";Nw/2;TAB(40);
3340         FIXED 3
3350         PRINT "Max Freq:";Maxfreq;TAB(60);"Freq Step:";Fstep
3360         STANDARD
3370         PRINT "Cutoff:";Cutoff;TAB(20);"Harmonic:";Cutoff;TAB(40);"Frequency:";Fstep*(Cutoff+1)
3380         PRINT RPT$("-",78)
3390         PRINT CHR$(27)&"1"
3400         STANDARD
3410         FOR I=1 TO N
3420            PRINT X(I,Numv),X0(I,0)
3430         NEXT I
3440      IF Cutoff>0 THEN GOTO 3510
3450         BEEP
3460         WAIT 50
3470         BEEP
3480         DISP "Please enter a cutoff (Currently ";Cutoff;", N =";Nw;")";
3490         INPUT Cutoff
3500         GOTO 3440
3510      P=0
3520      S1=-1
3530      N1=DROUND(LOG(Nw)/LOG(2),4)    ! LOG (N+1)
3540      N3=N1                          !    2
3550      N2=INT(Nw/2+.0001)
3560      F=2/Nw
3570      RETURN
3580 Fourier_t:P=2
3590      FOR X=0 TO Nw-1
3600         Xf=X
3610         IF X<>INT(Nw/2+.0001) THEN GOTO 3640
3620            X0(X,0)=X0(X,0)/2
3630            X1(X,0)=X1(X,0)/2
3640         IF X>Nw/2 THEN X0(X,0)=0
3650         IF X>Nw/2 THEN X1(X,0)=0
3660         X0(X,1)=-X1(X,0)*Xf
3670         X1(X,1)=X0(X,0)*Xf
3680         X0(X,2)=-X1(X,1)*Xf
3690         X1(X,2)=X0(X,1)*Xf
3700      NEXT X
3710      X0(0,0)=X0(0,0)/2
```

```
3720    IF NOT Option THEN GOTO 3810
3730        PRINTER IS 16
3740        PRINT CHR$(27)&"m";PAGE;
3750        PRINT TAB(30);"FOURIER TRANSFORM";LIN(2)
3760        PRINT "HARMONIC","FREQUENCY","COS","SIN"
3770        PRINT CHR$(27)&"l"
3780        FOR X=0 TO Cutoff
3790            PRINT X,(X+1)*Fstep,X0(X,0),-X1(X,0)
3800        NEXT X
3810    S1=1
3820    N3=N1
3830    N2=INT(Nw/2+.0001)
3840    F=1
3850    RETURN
3860 Transform:! FAST FOURIER TRANSFORM
3870    FOR L=1 TO N1
3880        K=0
3890        N3=N3-1
3900        FOR I=1 TO N2
3910            M=INT(K/2^N3)
3920            GOSUB Bitreversing
3930            C=COS(2*PI*M1/Nw)
3940            S=SIN(2*PI*M1/Nw)*S1
3950            FOR I2=0 TO P
3960                T0=C*X0(K+N2,I2)-S*X1(K+N2,I2)
3970                T1=S*X0(K+N2,I2)+C*X1(K+N2,I2)
3980                X0(K+N2,I2)=X0(K,I2)-T0
3990                X1(K+N2,I2)=X1(K,I2)-T1
4000                X0(K,I2)=X0(K,I2)+T0
4010                X1(K,I2)=X1(K,I2)+T1
4020            NEXT I2
4030            K=K+1
4040        NEXT I
4050        K=K+N2
4060        IF K<Nw THEN GOTO 3900
4070        N2=INT(N2/2+.0001)
4080    NEXT L
4090    FOR K=0 TO Nw-1
4100        M=K
4110        GOSUB Bitreversing
4120        IF M1<=K THEN GOTO 4210
4130        FOR I2=0 TO P
4140            T0=X0(K,I2)
4150            T1=X1(K,I2)
4160            X0(K,I2)=X0(M1,I2)
4170            X1(K,I2)=X1(M1,I2)
4180            X0(M1,I2)=T0
4190            X1(M1,I2)=T1
4200        NEXT I2
4210    NEXT K
```

```
4220    FOR X=0 TO Nw-1 ! SCALE FFT OUTPUT
4230        FOR I2=0 TO P
4240            X0(X,I2)=X0(X,I2)*F
4250            X1(X,I2)=X1(X,I2)*F
4260        NEXT I2
4270    NEXT X
4280    RETURN
4290 Bitreversing:M1=0   ! BIT REVERSING M TO M1
4300    FOR C=1 TO N1
4310        M1=M1*2
4320        IF 2*INT(M/2)<>M THEN M1=M1+1
4330        M=INT(M/2)
4340    NEXT C
4350    RETURN
4360 Cutoff:FOR I=Cutoff+1 TO Nw
4370        FOR D=0 TO 2
4380            X0(I,D)=0
4390            X1(I,D)=0
4400        NEXT D
4410    NEXT I
4420    RETURN
4430 Printinverse:IF NOT Option THEN RETURN
4440    PRINTER IS 16
4450    PRINT CHR$(27)&"m";PAGE;
4460    PRINT TAB(23);"  TRANSFORMED  DATA  ";LIN(2)
4470    PRINT " N ","DISPLACEMENT","VELOCITY","ACCELERATION";LIN(1)
4480    PRINT "    ","Orig  Transf";LIN(1)
4490    FOR I=1 TO N
4500        PRINT I,
4510        FIXED 5
4520        PRINT X(I,Numv);X0(I,0)+(Slope*I+Shift),X0(I,1)*(2*PI/Duration)+Slope/Time,X0(I,2)*(2*PI/Duration
)^2
4530        STANDARD
4540    NEXT I
4550    STANDARD
4560    RETURN
4570 Plot:  INPUT "Please enter the derivative [0,1,2,-1=Original,-2=EXIT]",D
4580    IF D=-2 THEN RETURN
4590    Yx=-9E99
4600    Ym=9E99
4610    FOR I=1 TO N
4620        IF D>-1 THEN GOTO 4660
4630            Yx=MAX(Yx,X(I,Numv))
4640            Ym=MIN(Ym,X(I,Numv))
4650        GOTO 4760
4660        IF D>0 THEN GOTO 4700
4670            Yx=MAX(Yx,X0(I,D)+(Slope*I+Shift))
4680            Ym=MIN(Ym,X0(I,D)+(Slope*I+Shift))
4690            GOTO 4760
4700        IF D>1 THEN GOTO 4740
```

```
4710            Yx=MAX(Yx,X0(I,D)*(2*PI/Duration)+Slope/Time)
4720            Ym=MIN(Ym,X0(I,D)*(2*PI/Duration)+Slope/Time)
4730        GOTO 4760
4740            Yx=MAX(Yx,X0(I,D)*(2*PI/Duration)^2)
4750            Ym=MIN(Ym,X0(I,D)*(2*PI/Duration)^2)
4760    NEXT I
4770    Xx=Time*(I-1)
4780    FIXED 5
4790    DISP "SCALE: ";0;",";Xx;",";Ym;",";Yx;"   (press CONTINUE)"
4800    STANDARD
4810    PLOTTER IS 7,5,"9872A"
4820    LOCATE 20,110,20,90
4830    SCALE 0,Xx,Ym,Yx
4840    PAUSE
4850    FOR I=1 TO N
4860        IF D)-1 THEN GOTO 4900
4870            PLOT Time*(I-1),X(I,Numv)
4880            PENUP
4890        GOTO 4930
4900            IF D=0 THEN PLOT Time*(I-1),X0(I,D)+(Slope*I+Shift)
4910            IF D=1 THEN PLOT Time*(I-1),X0(I,D)*(2*PI/Duration)+Slope/Time
4920            IF D=2 THEN PLOT Time*(I-1),X0(I,D)*(2*PI/Duration)^2
4930    NEXT I
4940    PENUP
4950    GOTO Plot
4960 Return:FOR I=1 TO N      !  TRANSFER NEW DATA SET .
4970        X(I,Numv)=X0(I,0)+(Slope*I+Shift)
4980        Vel(I,Numv)=X0(I,1)*(2*PI/Duration)+Slope/Time
4990        Acc(I,Numv)=X0(I,2)*(2*PI/Duration)^2
5000    NEXT I
5010    RETURN
5020 ! ---------------------------------------------------------------------
5030 DEF FNFourier_n(N)
5040    Np1=N+1
5050    N1=DROUND(LOG(Np1)/LOG(2),4)             ! LOG base 2 (N+1)
5060    IF N1()INT(N1) THEN N1=INT(N1)+1
5070    Nw=2^N1
5080 RETURN Nw
5090 FNEND
```

```
7400 End:!
7410 ! File: Grftrc                    Cartridge: GRAPHICS (1)
7420 ! Date: March, 1983 (Update)     Author: P.J.Thiessen
7430 ! Desc: This subprogram will plot stick figures over a graph that has been
7440 ! previously plotted. The SCALE and LOCATION arrays must be defined as wel
7450 ! as the X axis array.  These arrays are passed and allow the subprog to
7460 ! set up the plotter so that stick figures are plotted over the graph.
7470 ! Keys: GRAPH,STICK,PLOT,TRACE,OVER TOP,SUB
7480 ! ----------------------------------------------------------------------
7490 Graphtrace:SUB Graphtrace(X(*),Y(*),T(*),S(*),L(*),Numfrms,Numpts)
7500 DIM F(100),Jnt(100),Lt(100),L1(100)
7510 LOCATE L(1),L(2),L(3),L(4)
7520 SCALE S(1),S(2),S(3),S(4)
7530 PRINTER IS 16
7540 PRINT PAGE;LIN(7);TAB(22);" STICK FIGURE TRACING SUBPROGRAM ";LIN(1)
7550 PRINT "   The purpose of this program is to trace the body position of a subject"
7560 PRINT "onto a graph.  A graph must have been created before attempting to make a "
7570 PRINT "tracing so that the X-axis parameters have been established.  The following"
7580 PRINT "procedure will be used:"
7590 PRINT LIN(1);TAB(60);"Continued ...."
7600 DISP "Press CONTINUE for the procedure ...."
7610 PAUSE
7620 PRINT PAGE;"TRACING PROCEDURE:";LIN(2);CHR$(27)&"1";
7630 PRINT "  (1)  You will be asked the number of tracings to be made, and the numbers of"
7640 PRINT "       frames to be plotted";LIN(1)
7650 PRINT "  (2)  The tracings will be made over the X-ccordinate corresponding to the "
7660 PRINT "       frame(s) defined, but you will need to enter the Y-coodinate of the "
7670 PRINT "       of the tracing.  The Y-coordinate must be defined in GDU's (see Plotter"
7680 PRINT "       ROM Programming Manual pg. 4)";LIN(1)
7690 PRINT "  (3)  You will also be asked to define an area for the tracing to be plotted"
7700 PRINT "       within.  The area must also be defined in GDU's (suggested size 7,8).";LIN(1)
7710 PRINT "  (4)  Next you will be asked to define the initial LINE TYPE, and the number"
7720 PRINT "       of LINE TYPE changes you wish to make (entering zero means no changes)";LIN(1)
7730 PRINT TAB(60);"Continued ....";LIN(1)
7740 DISP "Press CONTINUE ...."
7750 PAUSE
7760 PRINT PAGE;"  (5)  If you wanted to make LINE TYPE changes then the next step would be to"
7770 PRINT "       define the changes.  This is done by specifying the joint number of the"
7780 PRINT "       change, the LINE TYPE, and WIDTH.  The LINE TYPE will then be changed"
7790 PRINT "       just before plotting the joint defined.  The LINE TYPE will remain in"
7800 PRINT "       effect until a new LINE TYPE is defined or a new tracing is begun.";LIN(1)
7810 PRINT "  (6)  Finally, the tracings will be made above their corresponding X-"
7820 PRINT "       coordinates.  A dot will be plotted just below each tracing correspond-"
7830 PRINT "       to the exact X-coordinate for that tracing."
7840 INPUT "Do you want to flip the X coordinates [Y/N]",Flip$
7850 IF Flip$<>"Y" THEN GOTO 7870
7860     MAT X=(17400)-X
7870 DISP "How many tracings do you want to make (Frames:";Numfrms;")";
7880 INPUT Nf
7890 REDIM F(1:Nf)
```

```
7900 DISP "Please enter the ";CHR$(132);Nf;CHR$(128);" frames to be plotted";
7910 INPUT F(*)
7920 GOSUB Getinitialpos
7930 GOSUB Getlinetypes
7940 GOSUB Plotter_ok
7950 DISP "Ready to begin plotting -- press CONTINUE"
7960 PAUSE
7970 FOR C=1 TO Nf
7980      GOSUB Getmaxmin
7990      GOSUB Plotracing
8000      IF C<Nf THEN GOSUB Getnewpos
8010 NEXT C
8020 PRINT CHR$(27)&"m";PAGE
8030 IF Flip$="Y" THEN MAT X=(17400)-X    ! Flip back to original form
8040 DISP " Tracing Subprogram completed "
8050 SUBEND
8060 Getinitialpos:GOSUB Plotter_ok
8070        LOCATE L(1),L(2),L(3),L(4)
8080        SCALE S(1),S(2),S(3),S(4)
8090        MOVE T(F(1)),S(3)
8100        SETGU
8110        CURSOR Xc,A
8120        INPUT "Please enter the Y coord. for the tracing(s)",Ymin
8130        MOVE Xc,Ymin
8140        INPUT "Please enter the width and height for the tracing(s)",W,H
8150        Xmin=Xc-W/2
8160        Xmax=Xc+W/2
8170        Ymax=Ymin+H
8180        DISP "Ready to outline the area -- press CONTINUE"
8190        PAUSE
8200        MOVE Xmin,Ymin
8210        MOVE Xmin,Ymax
8220        MOVE Xmax,Ymax
8230        MOVE Xmax,Ymin
8240        MOVE Xmin,Ymin
8250        MOVE Xc,Ymin
8260        INPUT "Is this position acceptable for the first frame",Ac$
8270        IF Ac$="N" THEN GOTO Getinitialpos
8280        LOCATE Xmin,Xmax,Ymin,Ymax
8290        RETURN
8300 Getnewpos:LOCATE L(1),L(2),L(3),L(4)
8310        SCALE S(1),S(2),S(3),S(4)
8320        MOVE T(F(C+1)),S(3)
8330        SETGU
8340        CURSOR Xc,A
8350        Xmin=Xc-W/2
8360        Xmax=Xc+W/2
8370        LOCATE Xmin,Xmax,Ymin,Ymax
8380        RETURN
8390 Getmaxmin:Xsmax=Ysmax=-9E99
```

```
8400       Xsmin=Ysmin=9E99
8410       FOR P=1 TO Numpts
8420           IF X(F(C),P)>Xsmax THEN Xsmax=X(F(C),P)
8430           IF Y(F(C),P)>Ysmax THEN Ysmax=Y(F(C),P)
8440           IF X(F(C),P)<Xsmin THEN Xsmin=X(F(C),P)
8450           IF Y(F(C),P)<Ysmin THEN Ysmin=Y(F(C),P)
8460       NEXT P
8470       MOVE Xc,Ymin-.5
8471       DRAW Xc,Ymin-1
8480       CSIZE 1.75
8490       LORG 4
8500       LDIR PI
8510       LABEL "^"
8520       SETUU
8530       SHOW Xsmin,Xsmax,Ysmin,Ysmax
8540       RETURN
8550 Plotracing:!
8560       RESTORE Order1
8570       DISP "Plotting frame ";CHR$(129);F(C);CHR$(128)
8580       LINE TYPE Lt,Ll
8590       Linecount=1
8600       FOR I=1 TO 27
8610           READ P
8620           IF P=-1 THEN GOTO 8680
8625               PLOT X(F(C),P),Y(F(C),P)
8630               IF P<>Jnt(Linecount) THEN GOTO 8670
8640                   LINE TYPE Lt(Linecount),Ll(Linecount)
8650                   Linecount=Linecount+1
8670           GOTO 8690
8680               PENUP
8690       NEXT I
8700       PENUP
8710       IF Numpts<=21 THEN GOTO 8780
8720           FOR P=P+1 TO Numpts
8730               IF P<>Jnt(Linecount) THEN GOTO 8760
8740                   LINE TYPE Lt(Linecount),Ll(Linecount)
8750                   Linecount=Linecount+1
8760               PLOT X(F(C),P),Y(F(C),P)
8770           NEXT P
8780       LINE TYPE 1,4
8790       RETURN
8800 Order1:DATA 1,2,3,4,5,6,-1,5,7,8,9,10,-1,5,11,12,13,14,15,16,-1,11,17,18,19,20,21
8810 Getlinetypes:INPUT "Please enter the initial line type (type,length)",Lt,Ll
8820       INPUT "How many changes in line type do you want",Numch
8830       FOR I=1 TO Numch
8840           INPUT "Please enter the joint number, line type, and length",Jnt(I),Lt(I),Ll(I)
8850       NEXT I
8860       RETURN
8870 Plotter_ok:STATUS 7,5;Status
8880       IF NOT BIT(Status,7) THEN RETURN
```

```
8890    BEEP
8900    DISP "Please turn PLOTTER chart load button off"
8910    STATUS 7,5;Status
8920    IF NOT BIT(Status,7) THEN GOTO 8940
8930    GOTO 8890
8940    DISP
8950    RETURN
```

Appendix C

RAW DATA FROM SUBJECTS

RAW DATA SOMERSAULT

Subjects	Sex	Age	Height (mm)	Weight (kg)	Score (10)	Angle of Contact (rad)	Angle of Take-off (rad)	Angular Velocity (rad/s)
Trevor Stoesz	M	11	1320	26.4	7.3	1.941	1.424	-4.316
Mike Gifford	M	20	1737	68.5	8.0	1.936	1.526	-3.412
Randy Fleisher	M	15	1532	47.2	4.0	2.078	1.536	-3.389
John Harris	M	20	1709	69.0	8.0	1.899	1.538	-3.011
Chris Baraniuk	M	15	1650	53.3	6.9	1.911	1.484	-3.889
Ron Bahauad	M	25	1696	67.0	7.3	2.006	1.577	-3.902
Graham Tipples	M	17	1908	70.6	3.8	1.979	1.505	-2.788
Adrienne Rose	F	15	1551	44.6	6.0	2.001	1.505	-3.822
Lynette Wittmeier	F	12	1378	32.8	7.8	2.002	1.512	-5.061
Anne Matejicka	F	11	1508	42.7	4.8	1.959	1.479	-3.696
Jennifer Zalnasky	F	11	1444	36.7	4.0	1.907	1.370	-4.471
Kelly Richardson	F	11	1369	29.3	7.2	2.019	1.558	-4.188
Julie Hall	F	11	1422	31.1	6.0	2.070	1.629	-4.005

RAW DATA SOMERSAULT

Subjects	Centripetal Force (N)	Radius of Rotation during contact (m)	Angle of Transition during contact (rad)	Contact Horizontal Velocity (m/s)	Take-off Horizontal Velocity (m/s)
Trevor Stoesz	372.78	0.758	-0.518	4.698	3.086
Mike Gifford	870.49	1.092	-0.409	5.067	3.249
Randy Fleisher	495.36	0.914	-0.514	4.902	2.716
John Harris	652.52	1.043	-0.361	4.568	2.460
Chris Baraniuk	821.97	1.020	-0.428	5.572	3.179
Ron Bahauad	1045.38	1.025	-0.429	4.940	3.237
Graham Tipples	658.58	1.200	-0.474	4.406	2.893
Adrienne Rose	575.20	0.883	-0.497	5.305	2.996
Lynette Wittmeier	691.75	0.823	-0.491	5.551	3.192
Anne Matejicka	535.91	0.919	-0.480	4.991	3.092
Jennifer Zalnasky	605.74	0.826	-0.537	5.200	3.212
Kelly Richardson	439.17	0.855	-0.461	5.064	2.817
Julie Hall	356.41	0.715	-0.441	5.332	2.461

RAW DATA SOMERSAULT

Subjects	Horizontal Acceleration during contact (m/s^2)	Horizontal Force via Smith, 1983 (N)	Vertical Velocity Take-off (m/s)	Vertical Acceleration during extension (m/s^2)	Vertical Force via Smith, 1983 (N)
Trevor Stoesz	13.431	354.58	2.744	34.300	905.52
Mike Gifford	15.149	1037.68	3.136	31.360	2148.16
Randy Fleisher	13.662	644.84	2.646	26.460	1248.91
John Harris	17.318	1194.92	3.136	44.800	3091.20
Chris Baraniuk	21.755	1159.52	3.136	39.200	2089.36
Ron Bahauad	15.479	1037.08	3.136	39.200	2626.40
Graham Tipples	8.895	627.97	3.136	39.200	2767.52
Adrienne Rose	17.762	792.17	3.234	40.425	1802.95
Lynette Wittmeier	24.325	797.85	2.804	41.300	1354.64
Anne Matejicka	14.605	623.64	2.548	31.850	1359.99
Jennifer Zalnasky	16.574	608.25	2.744	34.300	1258.81
Kelly Richardson	20.424	598.44	3.038	37.975	1112.67
Julie Hall	26.097	811.60	2.744	34.300	1066.73

RAW DATA SOMERSAULT

Subjects	Ground Time (sec)	Force Time (sec)	Air Time (sec)	Resultant Force (N) Smith	Angle of Force (rad)	Resultant Force/ Body Wt.	Maximum Height Upwards G of G (m)
Trevor Stoesz	0.12	0.08	0.56	972.45	1.198	3.759	0.275
Mike Gifford	0.12	0.10	0.64	2385.66	1.121	3.544	0.360
Randy Fleisher	0.16	0.10	0.54	1405.56	1.094	3.039	0.196
John Harris	0.12	0.07	0.64	3314.11	1.202	4.901	0.417
Chris Baraniuk	0.11	0.08	0.64	2389.54	1.064	4.575	0.356
Ron Bahauad	0.11	0.08	0.64	2823.74	1.175	4.301	0.368
Graham Tipples	0.17	0.08	0.64	2837.87	1.348	4.102	0.272
Adrienne Rose	0.13	0.08	0.66	1969.31	1.157	4.506	0.439
Lynette Wittmeier	0.10	0.07	0.57	1572.13	1.039	4.891	0.407
Anne Matejicka	0.13	0.08	0.52	1496.17	1.141	3.575	0.207
Jennifer Zalnasky	0.12	0.08	0.56	1398.06	1.121	3.887	0.274
Kelly Richardson	0.11	0.08	0.62	1263.39	1.077	4.400	0.361
Julie Hall	0.11	0.08	0.56	1340.38	0.920	4.398	0.334

RAW DATA SOMERSAULT

Subjects	Change of Height C of G during contact (m)	Horizontal Distance C of G (m)	Horizontal Distance Toes (m)	Horizontal Force from smoothed data (N)	Vertical Force from smoothed data (N)	Vertical Force/ Body Wt.
Trevor Stoesz	0.163	1.728	2.106	- 651	1864	7.20
Mike Gifford	0.212	2.080	2.636	-1847	6350	9.46
Randy Fleisher	0.157	1.467	1.996	-1353	3033	6.56
John Harris	0.188	1.593	1.843	-2442	8361	12.37
Chris Baraniuk	0.189	2.034	2.383	-1438	6300	12.07
Ron Bahauad	0.214	2.072	2.539	-2796	6234	9.50
Graham Tipples	0.211	1.852	2.303	-1140	3890	5.62
Adrienne Rose	0.197	1.977	2.439	-1624	4106	9.39
Lynette Wittmeier	0.168	1.827	2.282	-1752	2943	9.17
Anne Matejicka	0.152	1.608	2.165	-1269	3307	7.19
Jennifer Zalnasky	0.122	1.798	2.264	-1019	2637	7.35
Kelly Richardson	0.194	1.747	1.993	- 889	1914	6.67
Julie Hall	0.171	1.378	1.585	- 480	2422	7.97

RAW DATA HANDSPRING TO SOMERSAULT

Subjects	Score	Angle of Contact (rad)	Angle of Take-off (rad)	Angular Velocity (rad/s)	Centripetal Force (N)	Radius of Rotation during contact (m)
Trevor Stoesz	6.0	2.155	1.536	-3.439	231.03	0.740
Mike Gifford	8.1	2.229	1.691	-2.832	578.88	1.053
Randy Fleisher	6.0	2.051	1.554	-3.108	420.42	0.922
John Harris	8.6	2.149	1.824	-2.708	552.12	1.091
Chris Baraniuk	6.7	2.168	1.700	-2.753	404.88	1.003
Ron Bahauad	6.5	2.153	1.712	-2.759	521.40	1.022
Graham Tipples	5.5	2.153	1.700	-2.666	603.78	1.203
Adrienne Rose	7.8	2.025	1.582	-3.169	430.27	0.961
Lynette Wittmeier	7.8	2.181	1.700	-3.432	328.83	0.851
Anne Matejicka	4.6	2.076	1.643	-3.099	389.40	0.950
Jennifer Zalnasky	4.0	2.093	1.570	-4.028	522.21	0.877
Kelly Richardson	5.8	2.202	1.617	-4.174	424.10	0.831
Julie Hall	6.8	2.089	1.755	-3.334	306.99	0.888

RAW DATA HANDSPRING TO SOMERSAULT

Subjects	Angle of Transition during contact (rad)	Contact Horizontal Velocity (m/s)	Take-off Horizontal Velocity (m/s)	Horizontal Acceleration during contact (m/s^2)	Horizontal Force via Smith, 1983 (N)
Trevor Stoesz	-0.619	3.588	2.068	8.447	223.01
Mike Gifford	-0.538	4.820	1.878	15.485	1060.71
Randy Fleisher	-0.497	3.334	2.209	7.029	331.79
John Harris	-0.325	3.963	1.496	20.560	1418.65
Chris Baraniuk	-0.468	3.347	1.678	9.820	523.40
Ron Bahauad	-0.441	3.428	1.722	10.659	714.13
Graham Tipples	-0.453	2.906	1.998	5.341	377.08
Adrienne Rose	-0.444	3.629	2.413	8.680	387.13
Lynette Wittmeier	-0.480	3.428	2.060	9.772	320.51
Anne Matejicka	-0.434	3.990	2.285	12.177	519.95
Jennifer Zalnasky	-0.524	3.352	2.801	4.234	155.40
Kelly Richardson	-0.584	3.847	2.582	9.035	264.73
Julie Hall	-0.333	3.472	2.109	13.635	424.05

RAW DATA HANDSPRING TO SOMERSAULT

Subjects	Vertical Velocity Take-off (m/s)	Vertical Acceleration during extension (m/s^2)	Vertical Force via Smith, 1983 (N)	Ground Time (sec)	Force Time (sec)	Air Time (sec)
Trevor Stoesz	2.450	24.500	646.80	0.18	0.10	0.50
Mike Gifford	2.940	26.727	1830.82	0.19	0.11	0.60
Randy Fleisher	2.646	26.460	1248.91	0.16	0.10	0.54
John Harris	3.332	47.600	3284.40	0.12	0.07	0.68
Chris Baraniuk	3.038	30.380	1619.25	0.17	0.10	0.62
Ron Bahauad	2.940	29.400	1969.80	0.16	0.10	0.60
Graham Tipples	3.136	31.360	2214.02	0.17	0.10	0.64
Adrienne Rose	3.234	35.933	1602.63	0.14	0.09	0.66
Lynette Wittmeier	2.842	35.525	1165.22	0.14	0.08	0.58
Anne Matejicka	2.744	34.300	1464.61	0.14	0.08	0.56
Jennifer Zalnasky	2.646	26.460	971.08	0.13	0.10	0.54
Kelly Richardson	2.842	28.420	832.71	0.14	0.10	0.58
Julie Hall	2.744	34.300	1066.73	0.10	0.08	0.56

RAW DATA HANDSPRING TO SOMERSAULT

Subjects	Resultant Force via Smith, 1983 (N)	Angle of Force (rad)	Resultant Force/ Body Wt.	Maximum Height Upwards C of G (m)	Change of Height C of G during contact (m)	Horizontal Distance C of G (m)
Trevor Stoesz	684.17	1.239	2.644	0.200	0.181	1.034
Mike Gifford	2115.98	1.046	3.152	0.327	0.297	1.127
Randy Fleisher	1292.23	1.311	2.794	0.186	0.203	1.193
John Harris	3577.69	1.163	5.291	0.499	0.201	1.017
Chris Baraniuk	1701.74	1.258	3.258	0.303	0.281	1.040
Ron Bahauad	2095.25	1.223	3.191	0.289	0.209	1.033
Graham Tipples	2245.90	1.402	3.246	0.250	0.278	1.278
Adrienne Rose	1648.72	1.334	3.772	0.392	0.248	1.593
Lynette Wittmeier	1208.50	1.302	3.760	0.343	0.199	1.195
Anne Matejicka	1554.17	1.230	3.714	0.243	0.206	1.280
Jennifer Zalnasky	983.44	1.412	2.734	0.210	0.187	1.513
Kelly Richardson	873.77	1.263	3.043	0.285	0.234	1.498
Julie Hall	1147.92	1.192	3.766	0.279	0.181	1.181

RAW DATA HANDSPRING TO SOMERSAULT

Subjects	Horizontal Distance Toes (m)	Horizontal Force from smoothed data (N)	Vertical Force from smoothed data (N)	Vertical Force/ Body Wt.
Trevor Stoesz	1.284	-390	1035	4.01
Mike Gifford	1.151	-1540	3425	5.10
Randy Fleisher	1.659	-935	3047	6.67
John Harris	0.771	-2209	5301	7.84
Chris Baraniuk	1.160	-1165	3242	6.21
Ron Bahauad	1.477	-1849	7431	11.33
Graham Tipples	1.478	-1436	4115	5.96
Adrienne Rose	1.775	-1051	3832	8.77
Lynette Wittmeier	1.283	-1243	3280	10.21
Anne Matejicka	1.517	-655	2291	5.48
Jennifer Zalnasky	1.912	-411	1742	4.85
Kelly Richardson	1.826	-664	1812	6.31
Julie Hall	1.308	-587	1340	4.41