

- (20%) A 70 kg person is standing rigidly on the tip of the toes at A (Figure 1) so that the sole of the foot makes an angle of 15° with the floor. The mass center, G, in this position is 0.9 m from the back of the sole at C; each arm and leg carries half the total load. Distance \overline{AC} is 0.2 m; the outstretched arms make an angle of 20° with the horizontal, and line \overline{BG} , 0.85 m in length, makes an angle 30° with the horizontal. Friction acts so that all resultant forces pass through G. Determine the force components carried along the axes of the arms and legs.
- (20%) A man swings a hammer which rotates about the elbow through an angle of 110° to strike a nail. The mass of his forearm is 1.54 kg, with a 0.12 m distance from mass center to elbow, and a transverse centroidal moment of inertia of 0.01 kg m^2 , Figure 2. His hand, of mass 0.58 kg (that will be treated as a point mass), is located 275 mm from the elbow; the hammer consists of a circular handle with a mass of 0.25 kg and a length of 0.18 m with a 0.9 kg head at its tip that is also treated as a point mass. (a) If the man exerts a constant elbow moment of 50 N m, what is the velocity with which the head hits the nail and the angular acceleration of the arm? (b) If the rotation of the system is stopped in 0.05 sec, the mass of the nail is neglected, and the distance from elbow to nail is $L (= 275 \text{ mm} + 180 \text{ mm})$, what is the force transmitted to the hammer head by the object struck, assuming no rebound?
- (20%) Define torque in vector form, and draw a force diagram of torque being applied to an object to cause it to rotate. How could you increase the torque without increasing the magnitude of the applied force? Use the wheel of a wheelchair as an example to illustrate its linear and rotary motion.
- (20%) A windmill style softball pitcher executes a pitch in 0.65 seconds (Figure 3). If her pitching arm is 0.7 m long, what are the magnitudes of the tangential and radial accelerations on the ball just before the ball release when tangential ball speed is 20 m/s? What is the magnitude of the total acceleration on the ball at this point?
- (20%) Determine the period of small oscillations of a cylinder of radius r which rolls without slipping inside a curved surface of radius R (Figure 4).

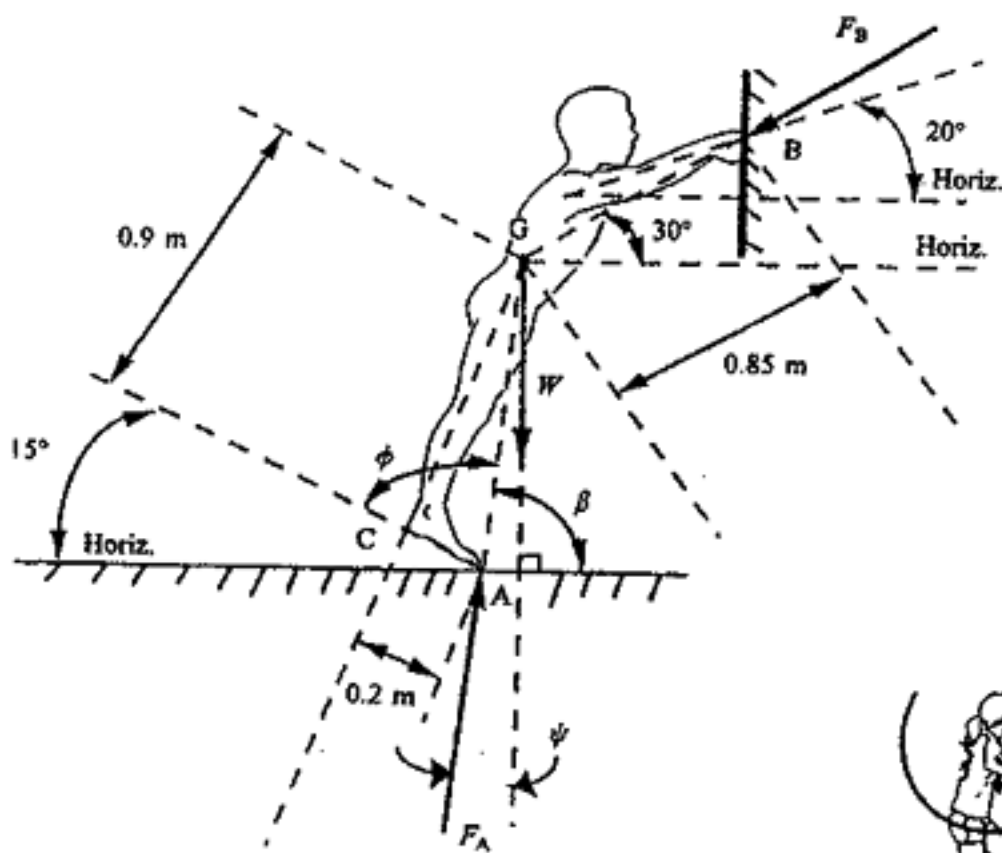


Figure 1

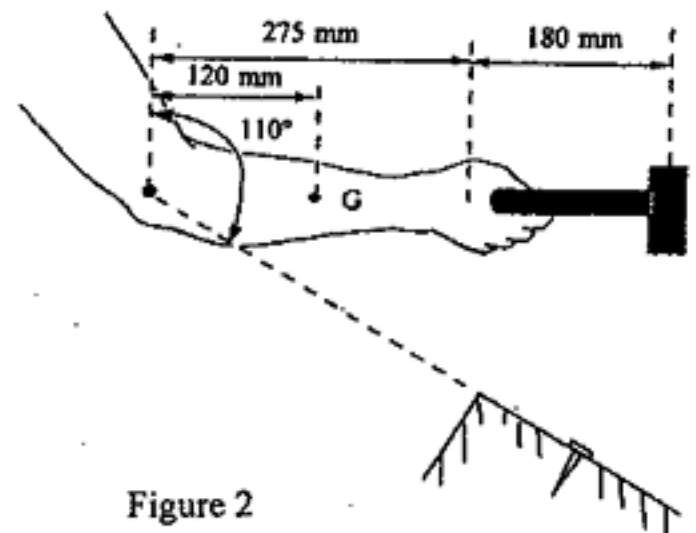


Figure 2



Figure 3

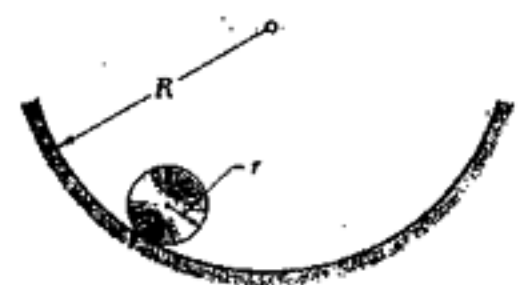


Figure 4