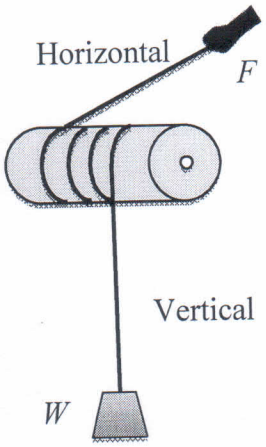
Show your steps clearly so that your thought process is easily discernible.

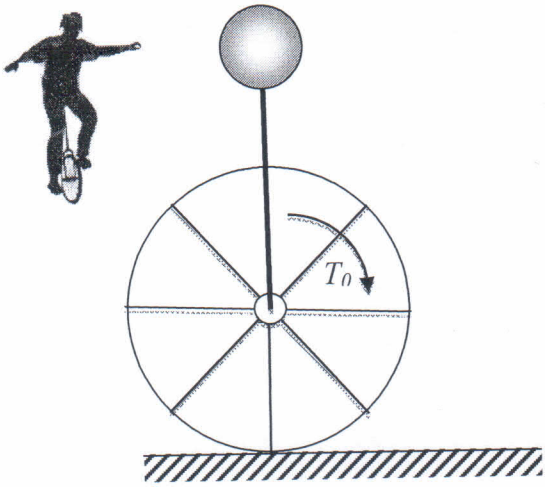
Question 1*(7 marks)*



A long cylindrical pulley has equally spaced grooves for a rope to wind and unwind. The coefficient of friction between the pulley and the rope is 0.5. A weight W is hanging on one end and a person is pulling the rope at the other end as shown in the figure.

- What should be the minimum force F to just hold the weight in position?
- By how many more turns should the rope wind on the pulley to reduce the person's effort by 50%?

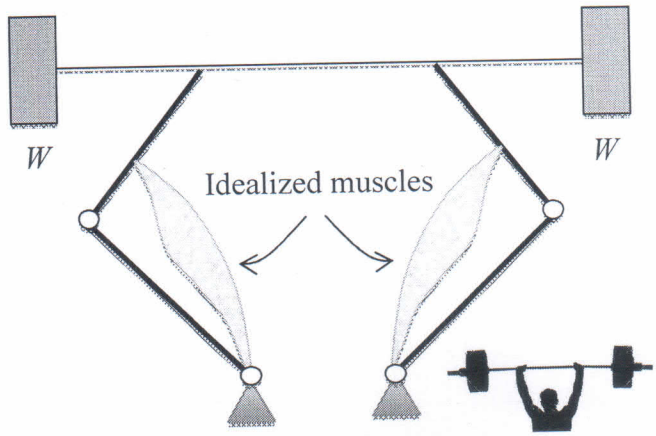
Question 2 *(9 marks)*



A person riding a unicycle is modeled as a mass M attached rigidly to the hub of a wheel at a distance of L from the centre of the wheel. The rod connecting the mass and the centre of the wheel remains vertical as the wheel rotates and rolls on a straight road without slipping. Neglect the inertia of the wheel. The radius of the wheel is R. A constant torque T_0 is applied at the centre of the wheel as the person pedals (not shown in the figure) the wheel.

- Write the equation of motion of this system by identifying the degree of freedom, writing kinetic and potential energies, and using Lagrange's method.
- If the wheel starts from rest, how far along the road will it be after t seconds?
- (Extra 5 points) What will be the distance if the road is inclined at θ^o to the horizontal and there is gravity?

Question 3*(9 marks)*



A weight-lifter is holding up a massless rod of length a with weights W on either end. Her arms are modeled as hinged two-member systems with a single significant muscle group connected from the shoulder joint to a point that is b distance away from the elbow. If the distance between the two shoulders is d and that between the hands is c, what are the forces exerted by the muscles if the height from the shoulder to the rod is h? The lower and upper arms are of lengths l and u. Neglect mass of everything except the weights. Show the free-body-diagram(s).

Problem Set 1 for Practice

Kinetostatics

(Taken from *Engineering Mechanics: Statics*, Sixth Edition, J. L. Meriam and L. G. Kraige)

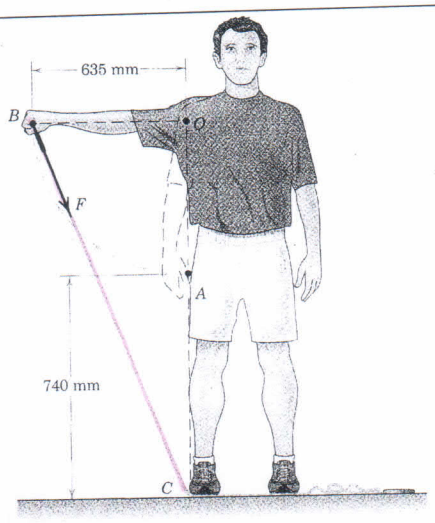


Fig. 1

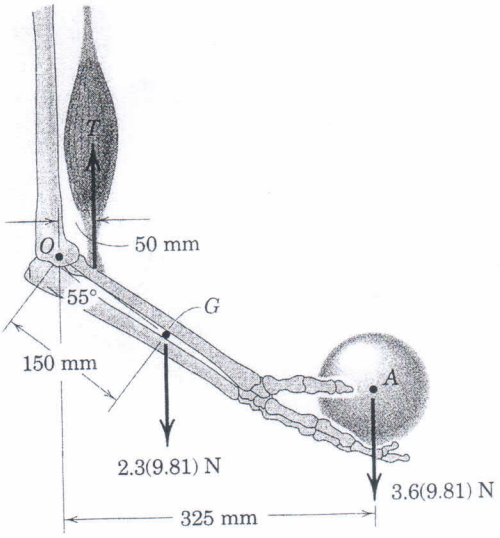


Fig. 2

1. An exerciser begins with his arm in the relaxed vertical position OA, at which the elastic band is unstretched as shown in Fig. 1. He then rotates his arm to the horizontal position OB. The spring constant of the band is 60 N/m. Determine the moment about O of the force that the hand exerts on the band B.

2. A schematic of the human lower arm are shown in Fig. 2. The mass of the lower arm is 2.3 kg. What must be the tension in the biceps so that the overall moment about O is zero?

3. With the weight of the person equally distributed on both feet, a man begins to slowly rise from a sitting position as shown in Fig. 3. Determine the tensile force F in the patellar tendon and the magnitude of the reaction force at O, which is at the contact point between the tibia and the femur.

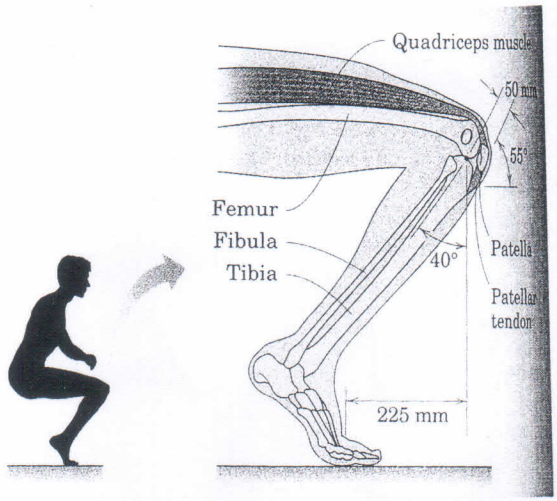


Fig. 3

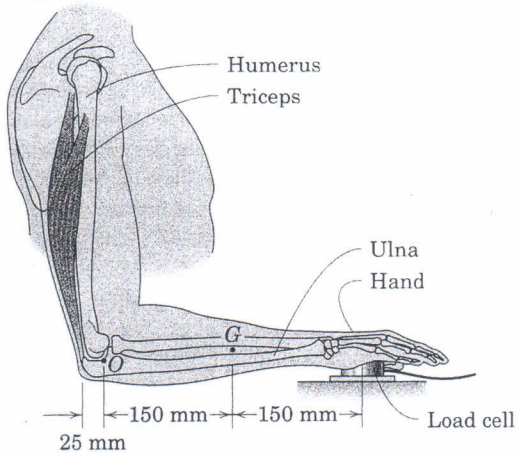


Fig. 4

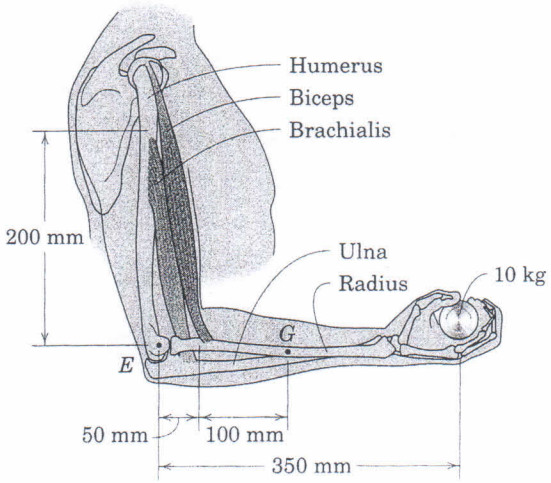


Fig. 5

4. In a procedure to evaluate the strength of the triceps muscle, a person pushes down on a load cell with the palm of his band as indicated in Fig. 4. If the load-cell reads 160 N, compute the vertical tensile force generated by the triceps muscle. The mass of the lower arm is 1.5 kg with mass center at G.

5. A person is performing slow arm curls with a 10-kg weight as shown in Fig. 5. The brachialis muscle group is the major factor in this exercise. Determine the magnitude of the muscle force and the reaction forces at the elbow joint.

6. A woman is holding a weight as shown in Fig. 6. Compute the force exerted by the deltoid muscle if the masses of the upper arm, lower arm, and the hand are 1.9 kg, 1.1 kg, and 0.4 kg, respectively?

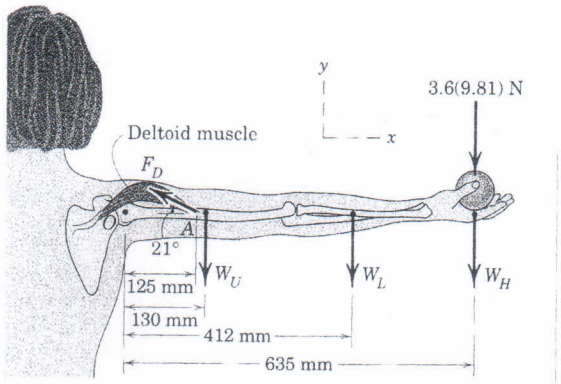


Fig. 6

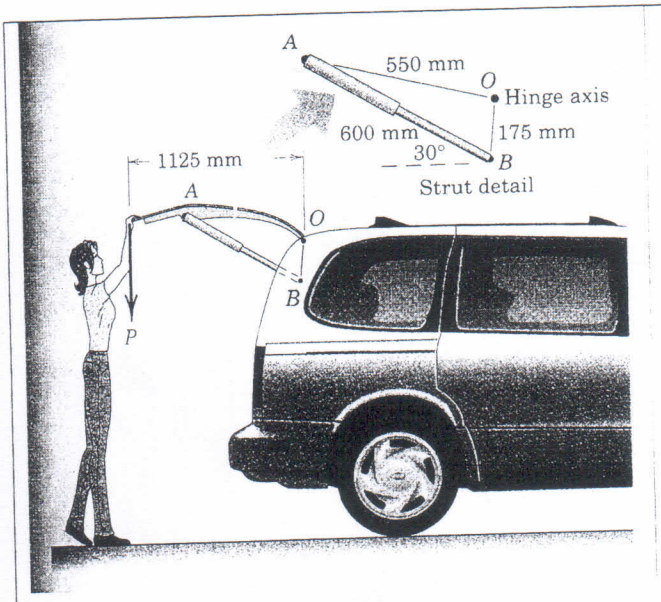


Fig. 7

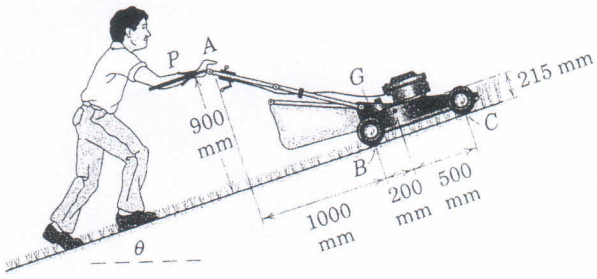


Fig. 8

7. The rear door of a van is to be closed with 40 N force applied vertically as shown in Fig. 7. If the mass of the door is 40 kg and its centre of mass is 37.5 mm directly below point A, determine the force in the hydraulic struts (there are two and only one is shown in the figure).

8. If the mass of the lawn–mower (see Fig. 8) with the grass-bag is 50 kg with its mass center at G and $\theta = 15°$, what force P must the person exert? Compute with and without friction if the friction coefficient it 0.3, for the impending motion of the mower?

9. Cowboys are seen to tie a horse to a horizontal pole without tying a knot. See Fig. 9. If the mass of the freely hanging rope is 0.06 kg and the coefficient of friction between the rope and pole is 0.7, what force does the horse feel in the direction it is tugging the rope?

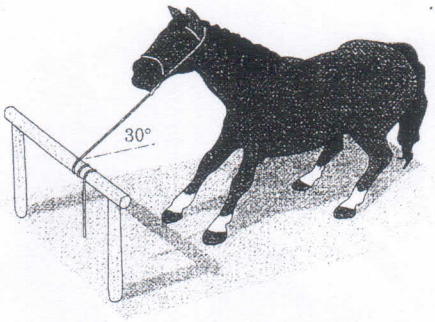


Fig. 9