PHYSICS – problem solving exercises
6a. Dynamics: rotation

Notes: air friction is neglected in all cases, magnitude of free fall acceleration is 10 m/s^2

Problem 1:
A 5 kg particle is uniformly moving on a circular path with radius of 6.0 m. Its speed is constant and it makes one revolution in 8 s. What is (a) the frequency, (b) the angular velocity, (c) centripetal acceleration, (d) the magnitude of its velocity, (e) the magnitude of the centripetal force, and (f) kinetic energy of its motion?

Problem 2:
A 3.0 kg particle undergoes a circular motion around a pivot point with an angular frequency of 2.0 rad/s. A magnitude of the centripetal force is 60 N. What is the radius of particle's path?

Problem 3:
A solid cylinder rotates about its central axis with a frequency 180 revolutions per minute. Its rotational potential energy is 620 J. What is its moment of inertia?

Problem 4:
A 2.0 kg particle moves on a circular trajectory with a diameter of 3.0 m. A centripetal force acting on this particle is 432 N. What is (a) the angular velocity, (b) the frequency, and (c) the kinetic energy of the particle?

Problem 5:
A particle revolves around a pivot point at a distance of 3.0 m doing 120 revolutions per 1 min. What is (a) the frequency, (b) the period, (c) the angular velocity, and (d) the centripetal acceleration of the particle?

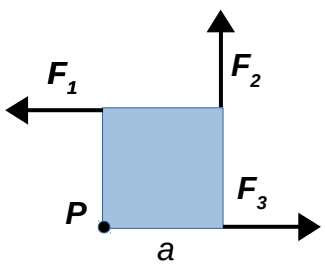
Problem 6:
A particle revolves around a pivot point at a distance of 3.0 m with a constant speed of 10 m/s. (a) What is the angular velocity of the particle? (b) What does it happen with the magnitude of the centripetal force, if the speed of the particle will be doubled?

Problem 7:
A 300 g particle revolves around a pivot point at a distance of 75 cm. What is a speed of the particle, if the magnitude of a centripetal force is 46 N?

Problem 8:
A 1 kg particle moves on a circular trajectory of a diameter of 10 m. What is the kinetic energy of the particle, if the magnitude of a centripetal acceleration is 32.0 m/s^2?

6b. Dynamics: torque and equilibrium

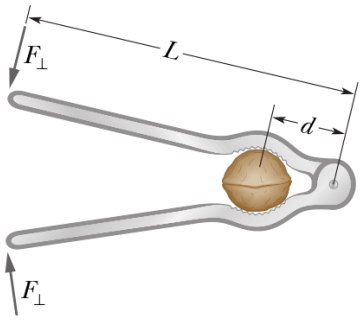
Problem 9:
The figure shows (in the overhead view) three forces of the same magnitude acting on a square that can rotate about point *P*. Rank the forces according to the magnitude of the torque they create about point *P*, greatest first.



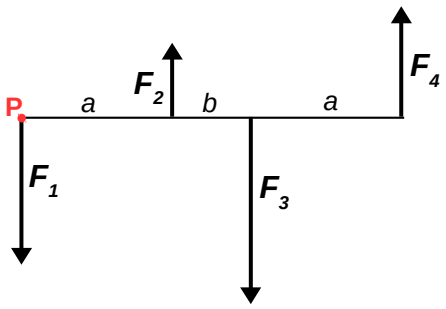
Problem 10:
A father and his son can use a seesaw. The son's and father's weights are 450 N and 820 N, respectively. What is a distance of the father from the pivot point if the son is sitting at a distance 3.4 m from the pivot and the seesaw is in equilibrium?

Problem 11:
A father and two children want to use a seesaw. Both children are sitting in the same side from the pivot point, the 45 kg son at a distance of 2.0 m from the pivot and the 20 kg daughter at a distance of 3.0 m from the pivot. What is a distance of the father from the pivot, if his mass is 75 kg?

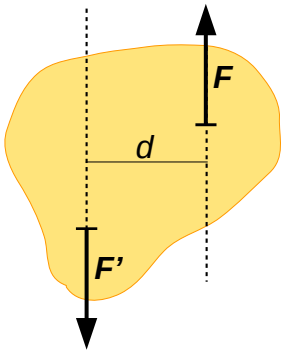
Problem 12:
To crack a certain nut in a nutcracker, forces with magnitudes of at least 40 N must act on its shell from both sides. For the nutcracker in the figure, with distances $L = 12$ cm and $d = 2.6$ cm, what are the force components $F_\perp$ (perpendicular to the handles) corresponding to that 40 N?



Problem 13:
What is the magnitude, direction and origin of the net force for a system in the figure. Magnitudes of particular forces are $F_1 = 400$ N, $F_2 = 200$ N, $F_3 = 500$ N, and $F_4 = 300$ N, distances between origins of forces are $a = 0.6$ m, and $b = 0.3$ m.[*Torque of the net force is the vector sum of the torques of individual forces for any selected pivot point – use e.g. point P*]



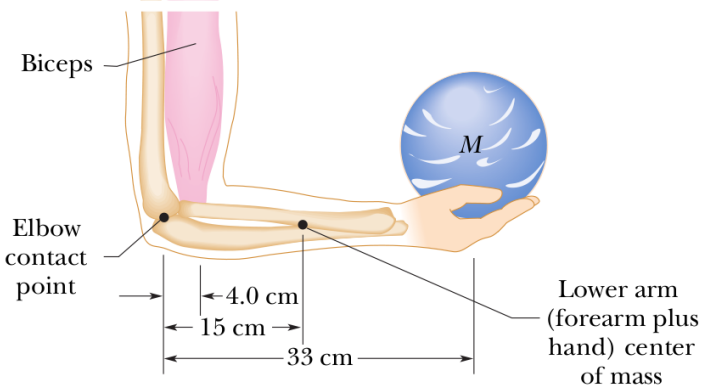
Problem 14:
What is the torque of a couple of forces ***F*** and ***F'*** in the figure? Both forces have the same magnitude of 10 N and a distance *d* between their parallel lines is 20 cm.



Problem 15:
There is a meter stick and two forces acting in the upward direction. Force F_1 acting on the left end is 40 N and force F_2 acting on the right end is 20 N. What is the magnitude, direction and position (measured from the left end) of a balancing force F_3?

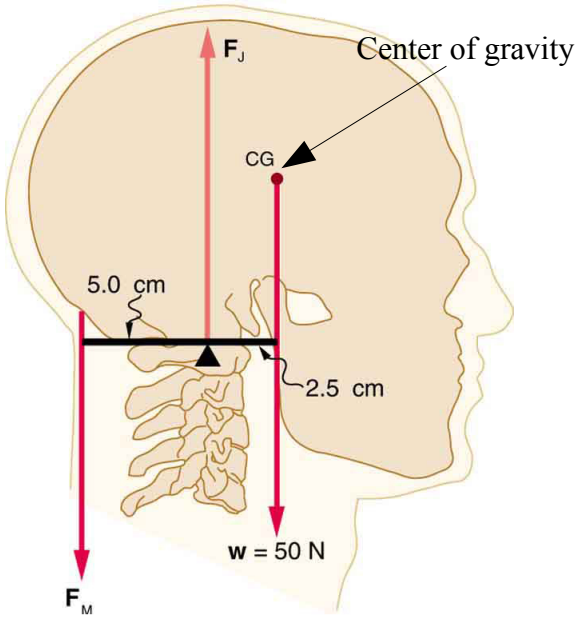
Problem 16:

A bowler holds a bowling ball (M = 7.2 kg) in the palm of his hand (see the figure). His upper arm is vertical; his lower arm (1.8 kg) is horizontal. What is the magnitude of (a) the force of the biceps muscle on the lower arm and (b) the force between the bony structures at the elbow contact point?



Problem 17:

Even when the head is held erect, its center of mass is not directly over the principal point of support (the atlanto-occipital joint). The muscles at the back of the neck should therefore exert a force to keep the head erect. That is why your head falls forward when you fall asleep in the class. (a) Calculate the force F_M exerted by these muscles? (b) What is the force F_J exerted by the pivot on the head?



6c. Dynamics: elasticity

Problem 18:
An 500 kg elevator is hanging on three steel cables. Each cable has a diameter of 1cm. What is a tensile stress at each cable? Assume weightless cables.

Problem 19:
What is the magnitude of a force acting on a steel wire with a radius of 0.5 mm which elongates this wire by 2%. The Young's modulus of steel is 220 GPa.

Problem 20:
A tensile stress of a cable hanging a block of mass is 1.50 MPa. A cross-section area of the cable is 2 cm^2. What is the mass of the block? Assume a weightless cable.

Problem 21:
Relative elongation of a wire caused by a force of 2.0 kN is 0.5%. What is the Young's modulus for the material of the wire, if a cross-section area is a square with a side length of 2.5 mm?

Problem 22:
A force applied on a wire increases 4× and a diameter of the wire increases 2×. How does change the tensile stress of the wire?

Problem 23:
A force applied on a wire increases 2×, a length of the wire increases 3×, and a cross-section area increases 4×. Calculate changes in absolute (ΔL) and relative elongation ($\Delta L/L$) of the wire.