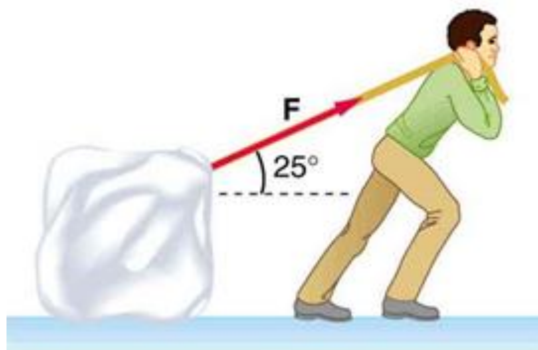
Drake Physics Prize Test (Part II)

STUDENT: **SCHOOL:** **PROCTOR:**

Please, circle your answers among the multiple choices and write down all your solutions in detail. If you need more paper, please, indicate the problem number you are solving, write your name and school name on each page and staple all your papers together.

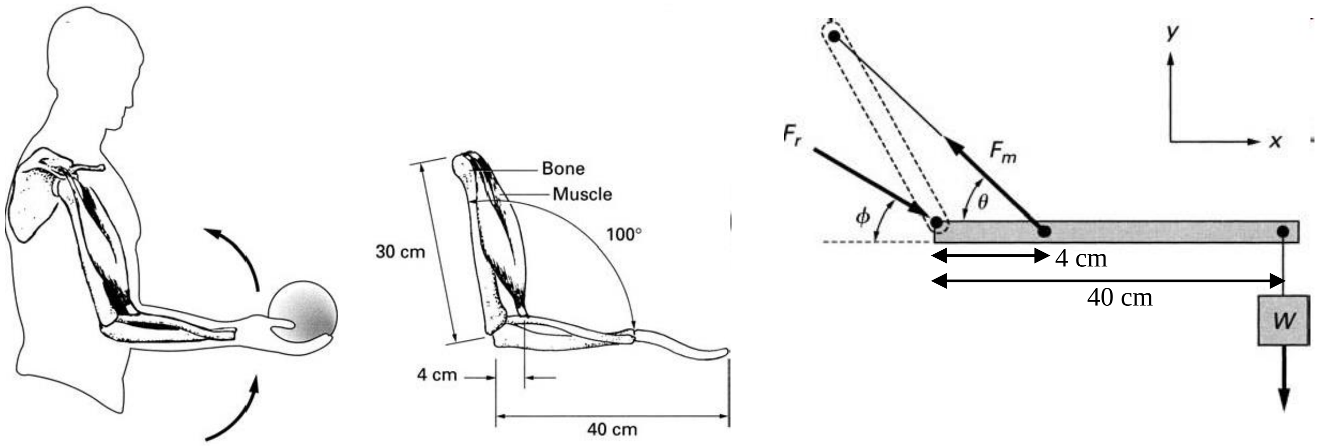
1. A person moves a 35.0 kg block of ice across a frozen lake by pulling it as shown in the figure. The magnitude of the pulling force **F** he exerts on the block is 100 N. The coefficients of static and kinetic friction for ice on ice are μ_s = 0.10 (static) and μ_k = 0.03 (kinetic).



1. Calculate the normal force the frozen lake exerts on the block of ice.
2. Write Newton's second law of motion for the block of ice and calculate its acceleration from this law.
3. What should the magnitude of the pulling force **F** be to move the block with constant speed (the angle of the force being 25° as in the figure)?
4. Calculate the minimum force the person must exert to get the block moving from rest (the angle of the force being 25° as in the figure).

(a) (1) 300.7 N (2) 4.6 m/s^2 (3) 20.4 N (4) 56.1 N
(b) (1) 300.7 N (2) 2.3 m/s^2 (3) 11.2 N (4) 36.2 N *
(c) (1) 300.7 N (2) 2.3 m/s^2 (3) 20.2 N (4) 15.7 N
(d) (1) 300.7 N (2) 2.3 m/s^2 (3) 11.2 N (4) 45.0 N
(e) (1) 300.7 N (2) 2.3 m/s^2 (3) 11.2 N (4) 70.1 N

2. Consider the lever representation of the elbow as a person is lifting a weight using the biceps muscle. $\boldsymbol{F_m}$ is the force by the biceps muscle, and $\boldsymbol{F_r}$ is the reaction force at the elbow. The weight of the forearm itself is 20 N; assume that this weight acts at the middle of the forearm (note that this weight in not drawn on the figure). The angle θ is 55°. When the person holds a weight $\boldsymbol{W}$, the force in the biceps muscle is measured to be 850 N.



1. What is the magnitude of the weight $\boldsymbol{W}$?
2. Determine the magnitude and direction of the reaction force, $\boldsymbol{F_r}$, at the elbow.

(a) (1) $W = 59.6$ N (2) $F_r = 128$ N, $\varphi = 30.2^o$
(b) (1) $W = 59.6$ N (2) $F_r = 233$ N, $\varphi = 69.7^o$
(c) (1) $W = 59.6$ N (2) $F_r = 516$ N, $\varphi = 61.5^o$
(d) (1) $W = 59.6$ N (2) $F_r = 786$ N, $\varphi = 51.7^o$ *
(e) (1) $W = 59.6$ N (2) $F_r = 786$ N, $\varphi = 72.3^o$

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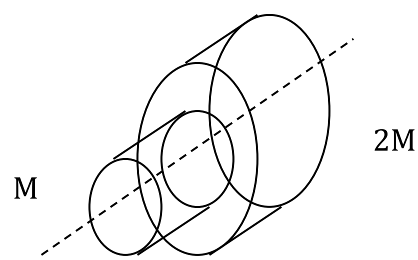
3. A spacecraft consists of two attached cylinders, assumed solid and uniform, initially rotating about their common longitudinal axis at a frequency of f_0 = 5 rpm, as shown. The first cylinder has mass M and radius R. The second has mass 2M and radius 2R. Rockets are fired to separate the two cylinders. After the separation the first cylinder (of mass M) rotates about its axis with frequency f while the second (of mass 2M) cylinder rotates at a frequency f/2. Both cylinders rotate in *the same direction* as the entire spacecraft did at the beginning. The separation occurs in outer space where there are no forces external to the spacecraft. Find the final frequency, f, of the first cylinder. (NOTE: the moment of inertia of a solid cylinder about its axis is ½ M R^2).



(a) 5 rpm
(b) 9 rpm *
(c) 12 rpm
(d) 15 rpm
(e) 18 rpm

4. The frequency of the siren of a fire-truck that is moving relative to a stationary pedestrian is perceived to be 620 Hz when the truck is approaching and 590 Hz when the truck is moving away. Find the speed of the truck. Take the speed of sound in the air to be 340 m/s.

(a) 20.0 m/s
(b) 16.8 m/s
(c) 12.4 m/s
(d) 10.3 m/s
(e) 8.40 m/s *

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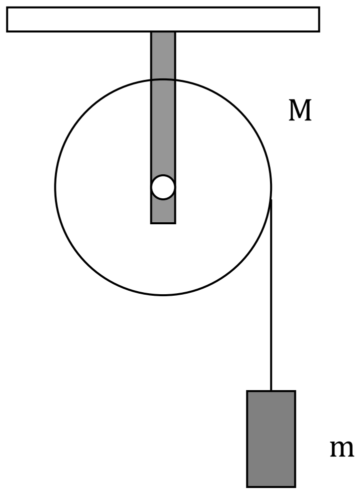
5. A light string that cannot extend is used to hang a mass m by being wound around a frictionless pulley of mass M in the shape of a solid cylinder of radius R. Find the acceleration of the mass m in terms of the acceleration due to gravity (g) and the other information given in the problem. (The moment of inertia of a solid cylinder about its axis is ½ M R^2).



(a) g
(b) Mg/m
(c) Mg/(2m + M)
(d) mg/(m + M/2) *
(e) mg/(m + M)

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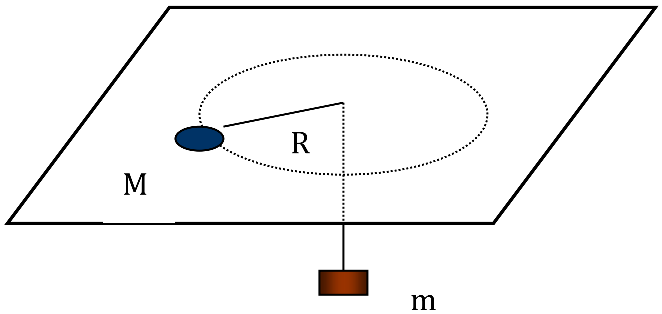
6. A flat puck of mass M = 1 kg is rotated on a horizontal frictionless table on a circle of radius R = 1 m at a constant speed. This is done by attaching the puck to a mass-less non-extendable rope that passes through a hole in the table. At the other end of the rope there is a mass m = 10 kg, hanging in equilibrium as shown. The speed of the puck is about



(a) 5 m/s
(b) 10 m/s *
(c) 15 m/s
(d) 20 m/s
(e) 25 m/s