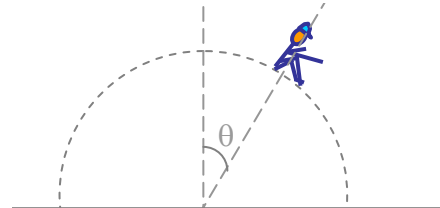
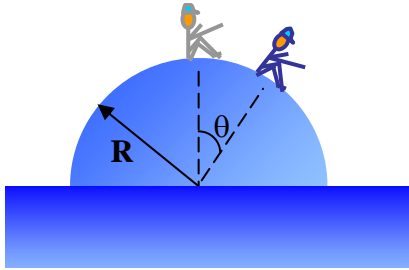


NAME _____

Note: To simplify calculation, use $g = 10 \text{ m/s}^2$ in this exam (unless otherwise stated explicitly).

1. A boy is seated on the top of a spherical mound of ice of radius R (see figure). He is given a very small push and starts sliding down the ice.



Answer here question 1A

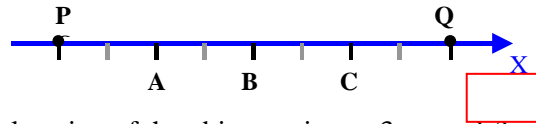
- 1.A In the space provided above, draw the free body diagram for the boy, indicating all the individual forces acting on the boy, label them with the proper name. Then, **draw an arrow** indicating the approximate direction of the net (or total) vector force acting on the boy.

- 1.B The angle $\theta = \theta_0$ at which the boy leaves the ice is equal to (in degrees):

- a) 13 **b) 48** c) 63 d) 635 e) NA

Hint: The normal force vanishes as he leaves the ice

2. 2A An object moves along the line from "P" to point "Q" in 6 seconds. Point B lies halfway between points P and Q



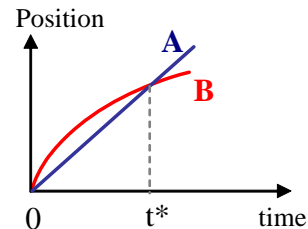
If we assumed that the object is **slowing down**, which of the labeled points A, B, or C *could* correspond to the location of the object at time $t=3$ seconds?

ANSWER **C**

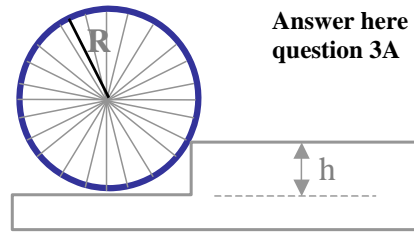
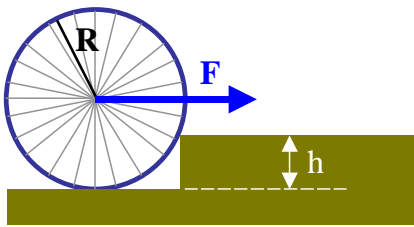
If we assumed that the object is **speeding up**, which of the labeled points A, B, or C *could* correspond to the location of the object at time $t=2$ seconds? ANSWER **A**

- 2B The graph shows position as a function of time for two trains running on parallel tracks. Which is true:

- a) At time t^* , both trains have the same velocity
 b) Both trains speed up all the time
c) Both trains have the same velocity at some time before t^*
 d) For $0 < t < t^*$, the speed of B is higher than the speed of A
 e) None of the above choices are correct.



3. A horizontal force F is applied at the axle of a wheel, of radius $R=30$ cm and mass M , in order to raise it over an obstacle of height $h=20$ cm.

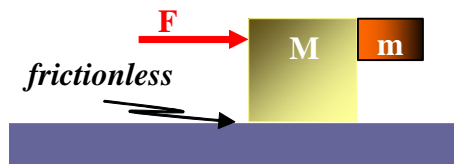


- 3A In the space provided above, draw the free body diagram for the wheel, indicating all the individual forces acting on the wheel, label them with the proper name (consider the wheel has already been lifted a bit).

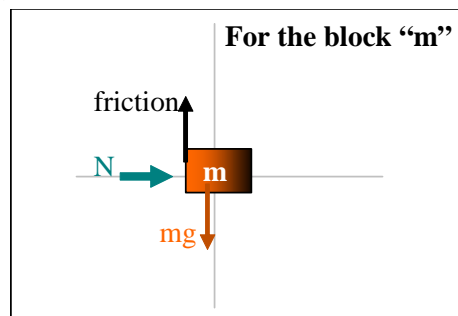
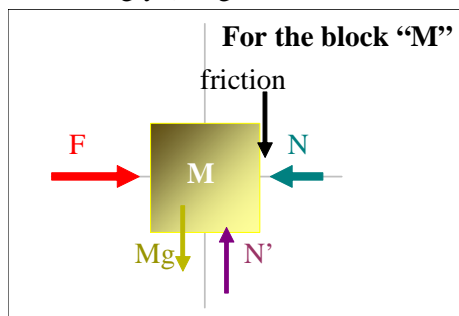
- 3B The minimum value for the magnitude of the force F necessary to raise the wheel over the obstacle is:

- a) $1.7 Mg$ b) $0.23 Mg$ c) $2.8 Mg$ d) $4.1 Mg$ e) NA

4. Two blocks of mass $m = 2$ Kg and $M=10$ Kg are not attached. The coefficient of static friction between the blocks is $\mu_s = 0.5$, but the surface beneath the larger block is frictionless.



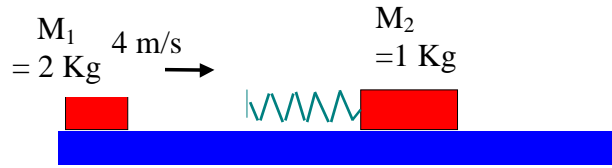
- 4A Make a free-body diagram for each of the blocks in the space provided below. Indicate explicitly ALL the forces acting on the corresponding block. Label the forces accordingly (weight, friction, normal, etc)



- 4B The minimum magnitude of the horizontal force F required to keep the smaller block from slipping down the larger block is (in Newtons):
To simplify calculations, use $g=10$ m/s².

- a) 20 b) 48 c) 240 d) 635 e) NA

5. A block of mass $M_1 = 2 \text{ Kg}$ slides along a frictionless table with a speed of 4 m/s . Directly in front of it, and at rest, is a block of mass $M_2 = 1 \text{ Kg}$. A massless spring with spring constant $k=200 \text{ N/m}$ is attached to the near side of M_2 , as shown in the figure.



5A When the spring is at its maximum compression, what is the velocity of the center of mass of the blocks?

- a) 4 m/s b) 1 m/s c) 2.6 m/s d) 1.7 m/s e) NA

5B What is the maximum compression of the spring?

- a) 0.09 m b) 0.23 m c) 0.67 m
d) 0.57 m e) NA

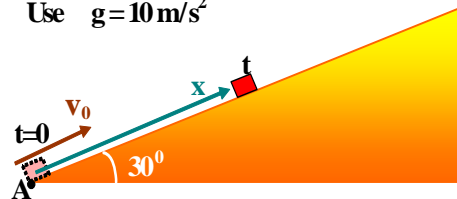
6. A block of mass $m = 0.8 \text{ Kg}$ slides up a rough ramp. At $t=0$ the block is at A (the bottom of the ramp) and its initial speed is 5 m/s .

There is friction
 $\mu_k = \frac{\sqrt{3}}{6} = 0.288$
 $\mu_s = 0.35$

At $t=0$
 $x=0$ and
initial speed: $v_0 = 5 \text{ m/s}$

 x : position
 t : time

Use $g = 10 \text{ m/s}^2$



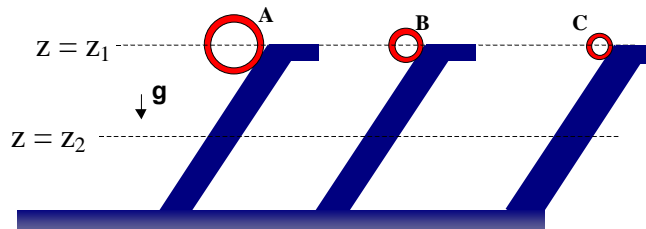
6A When the block reaches its highest position, what is the distance it has traveled along the ramp?

- a) 2.5 m b) 1.67 m c) 3.16 m d) 2 m e) NA

6B The time the block takes to reach its max height is:

- a) 0.67 sec b) 0.33 sec c) 0.28 sec d) 1 sec e) NA

7. The figure below shows three thin rings of different radius but all have the same mass. They are released from the same level $z = z_1$ and roll down the ground without slipping.



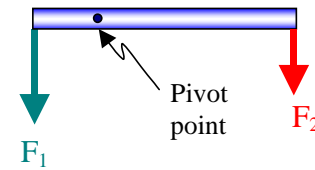
7A The speeds of their center of mass, when they pass the level $z = z_2$, have the following relationship:

- a) $V_A = V_B > V_C$ b) $V_A > V_B > V_C$ c) $V_A = V_B = V_C$
d) $V_A < V_B < V_C$ e) NA

7B Which of the following expression is correct?

- a) Since friction is involved in the rolling of the rings, the mechanical energy of the rings do not conserve
- b) All the rings shown in the figure have the same momentum of inertia (assuming the momentum of inertial are calculated with respect to the axis of rotation passing through their center of mass)
- c) Each ring rolls down with its center of mass traveling at constant velocity
- d) Each ring rolls down with its angular velocity remaining constant.
- e) NA

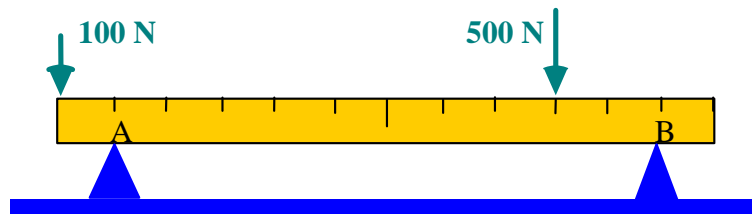
8. 8A The figure shows an overhead view of a meter stick that can pivot about the point indicated, which is to the left of the stick's midpoint. Two horizontal forces \vec{F}_1 and \vec{F}_2 , are applied to the stick. Only \vec{F}_1 is shown. Force \vec{F}_2 is perpendicular to the stick and is applied at the right end. If the stick is not to turn, indicate **both** the direction of \vec{F}_2 and answer whether the magnitude F_2 should be less, equal or greater than F_1 .



Circle your answer

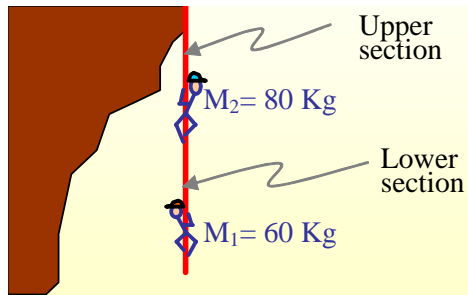
$F_2 < F_1$ $F_2 = F_1$ $F_2 > F_1$

8B A rectangular bar of uniform mass density, shown in the figure, is resting in EQUILIBRIUM. Draw the vector forces acting on the bar at the points A and B, AND find their corresponding magnitudes. **The weight of the bar is 40 N** and its length is 12 meters.



- a) $F_A = 230 \text{ N}$, $F_B = 410 \text{ N}$
- b) $F_A = 120 \text{ N}$, $F_B = 520 \text{ N}$
- c) $F_A = 320 \text{ N}$, $F_B = 320 \text{ N}$
- d) $F_A = 100 \text{ N}$, $F_B = 500 \text{ N}$
- e) NA

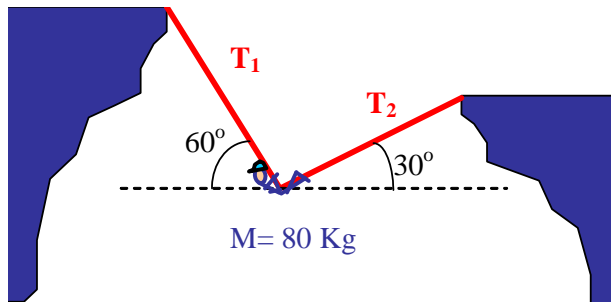
9. 9.A Two mountaineers of masses $M_1=60\text{ Kg}$ and $M_2= 80\text{ Kg}$ strangely happen to be hanging at rest on one rope in equilibrium over a cliff, as shown in the figure. Find the magnitude of the tensions in the two sections of the rope. (Assume $g = 10\text{ m/s}^2$).



Upper Section: $T_2 = 1400$

Lower Section: $T_1 = 600$

- 9.B An intrepid mountain climber of mass $M=80\text{ Kg}$ is resting in the awkward situation depicted in the figure. Find the magnitude of the tensions in the two supporting ropes.

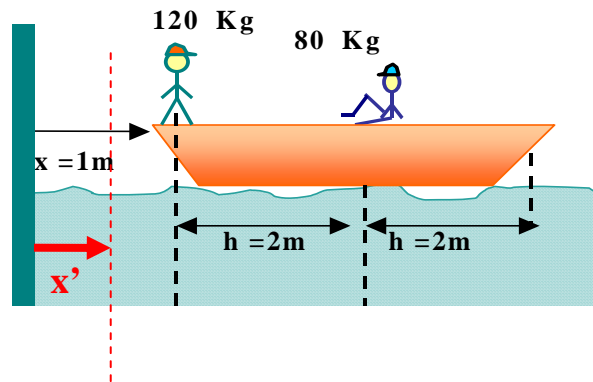


$T_2 = 400\text{ N}$

$T_1 = 693\text{ N}$

BONUS QUESTION (3 points)

Student A of mass $M_A = 80\text{ Kg}$ and student B of mass $M_B = 120\text{ Kg}$ are in a boat of mass 60 Kg on a clam lake. They are seated 2 meters apart. What will be the new position of the boat's left edge if the students decide to interchange places?



$x'_{\text{boat}} = \underline{\hspace{2cm}}$

$x'_{\text{boat}} \sim 0.7\text{ m}$

Helpful formulas

Average velocity = $\Delta \mathbf{x} / \Delta t$

instantaneous velocity $\mathbf{v} = d \mathbf{x} / dt$

Average acceleration = $\Delta \mathbf{v} / \Delta t$

instantaneous acceleration $\mathbf{a} = d \mathbf{v} / dt$

POTENTIAL ENERGY

Gravitational potential energy : $m g z$

Spring potential energy : $(1/2) k x^2$

FORCE and POTENTIAL ENERGY

$$\mathbf{F} = -\frac{\partial U}{\partial \mathbf{x}}$$

ROTATIONAL KINETIC ENERGY

$$\mathbf{K}_{\text{rot}} = (1/2) \mathbf{I} \omega^2$$

\mathbf{I} is the Momentum of Inertia

LINEAR MOMENTUM

$$\mathbf{P} = m \mathbf{v}$$

TORQUE

$$\boldsymbol{\tau} = \mathbf{r} \times \mathbf{F} \text{ (x indicates vector product)}$$

UNIFORM CIRCULAR MOTION

$$\mathbf{a} = v^2/R \text{ (centripetal acceleration)}$$

CENTER OF MASS

$$\vec{\mathbf{R}}_{CM} = \frac{1}{M} \sum_i m_i \vec{\mathbf{x}}_i$$

Motion under constant acceleration “a”

$$v = v_0 + a t$$

$$x - x_0 = v_0 t + (1/2) a t^2$$

$$v^2 = v_0^2 + 2 a (x - x_0)$$

Free fall $v_y = v_{0y} - g t$, $y - y_0 = v_{0y} t - (1/2) g t^2$, $v_y^2 = v_{0y}^2 - 2 g (y - y_0)$

$$x - x_0 = v_{0x} t$$

$$g = 9.8 \text{ m/s}^2 \text{ or } 32 \text{ ft/s}^2$$

UNIFORM CIRCULAR MOTION

Centripetal acceleration: $a = v^2/R$

Newton's second law

$$\mathbf{F} = m \mathbf{a}$$
