Physics 2A: Review

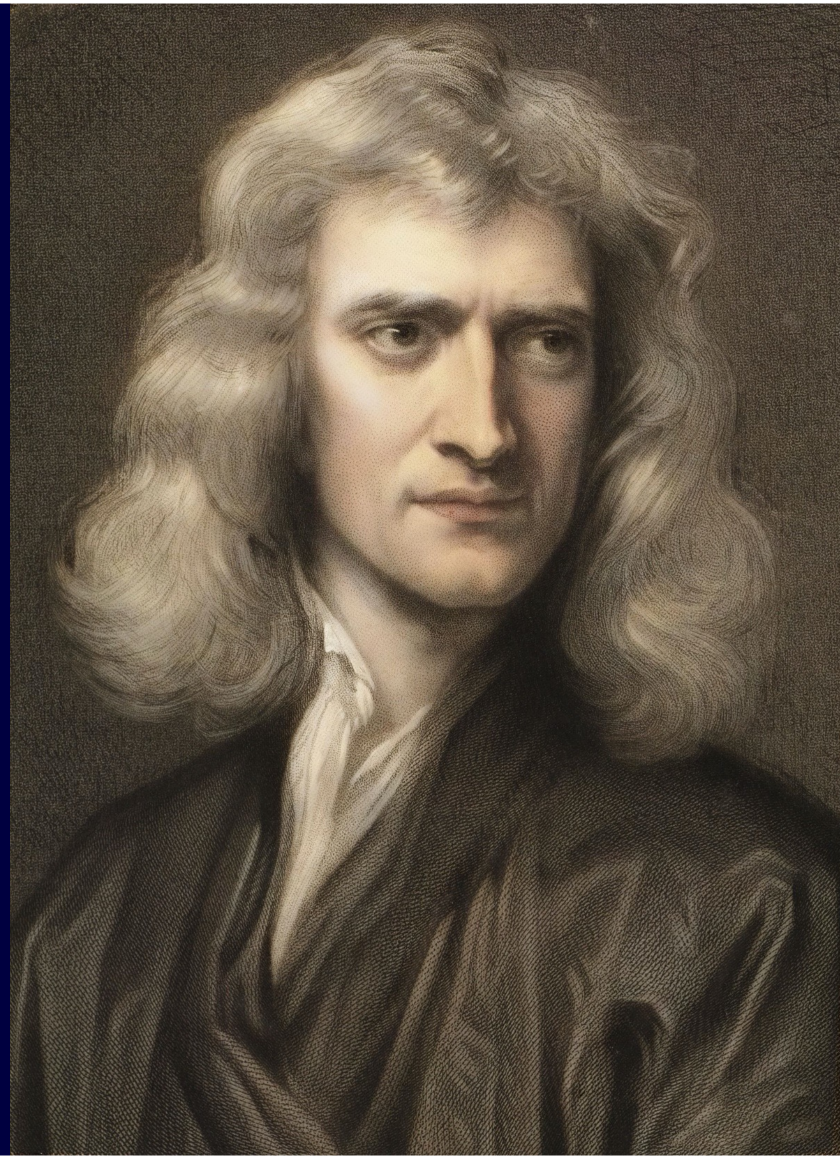
Agenda for Today

- Review

A) Yes

B) No

Start Recording!

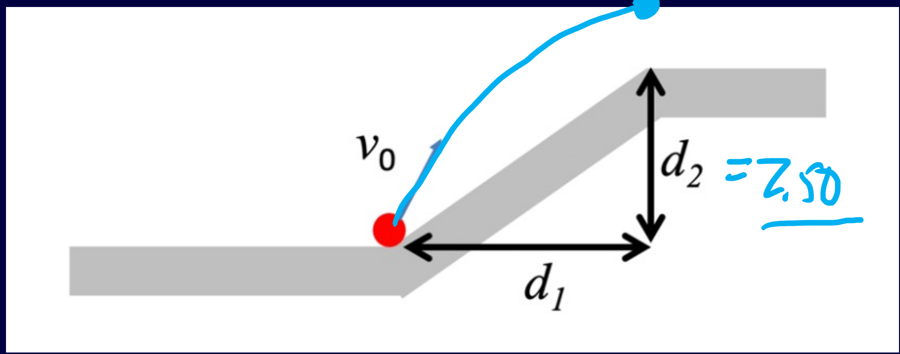


Clicker Question 1:

A ball is launched with a velocity of magnitude 10.0 m/s at an angle of 50.0 degrees relative to the horizontal. The launch point is at the base of a ramp of horizontal length d_1 = 5.00 m and height d_2 = 2.50 m, as in the figure below. At the top of the ramp the surface becomes level again. (a) Does the ball land on the ramp or on the top level surface? (b) How long after it is launched does it land?

What will be the height of the ball when it has travelled 5 m in the x-direction?

A. 2.51 m
B. 3.14 m
C. 3.80 m
D. 2.99 m
E. 4.13 m



$x_0 = 0$

$y_0 = 0$

$v_{0x} = 6.42 \, m/s$

$v_{0y} = 7.66 \, m$

$a_x = 0$

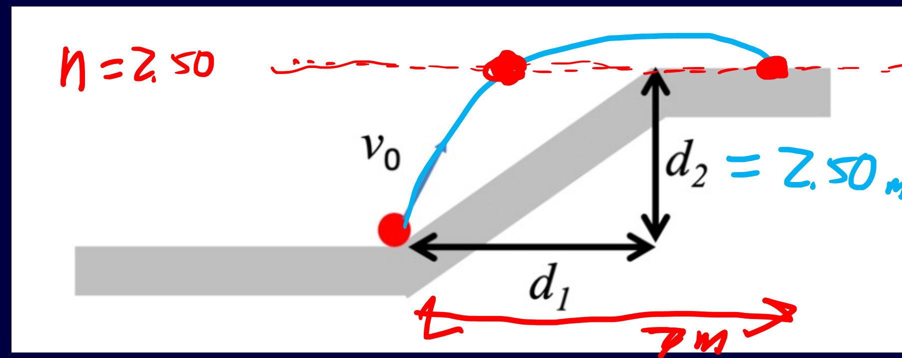
$a_y = -g$

$$y = \cancel{x_0} + v_{0y} t + \frac{1}{2} a t^2$$

$$= 7.66 \, m/s \, t - \frac{1}{2} g t^2$$

$$t = 0.778 \, s$$

$$= 2.99 \, m$$



$$y = 7.66\,m/s\,t - \frac{1}{2} g t^2$$

$$2.50\,m = 7.66\,m/s\,t - \frac{1}{2} g t^2$$

$$\frac{1}{2} g t^2 - 7.66\,\frac{m}{s}\,t + 2.50\,m = 0$$

$$t = \boxed{1.09\,s}, \quad 0.46\,s$$

A B

$$x = 6.42\,m/s\;t$$

$$= 6.42\,m/s\,(1.09\,s)$$

$$= 7\,m$$

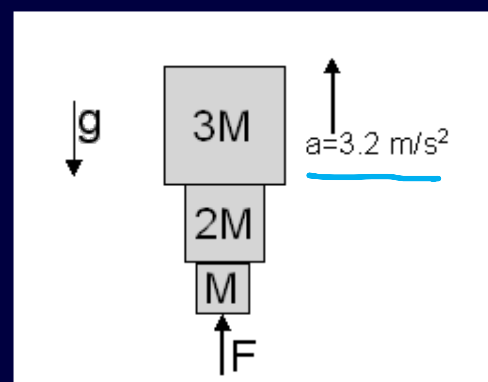
Clicker Question 2:

Three blocks are being accelerated upward by a force F applied to the bottom block as shown in the diagram. The mass of the bottom block is 7 kg, the mass of the middle block is 14 kg, and the top block is 21 kg. Compare the net force on the bottom block F_1 with the net force on the top block F_3.

A. $F_1 = F_3$

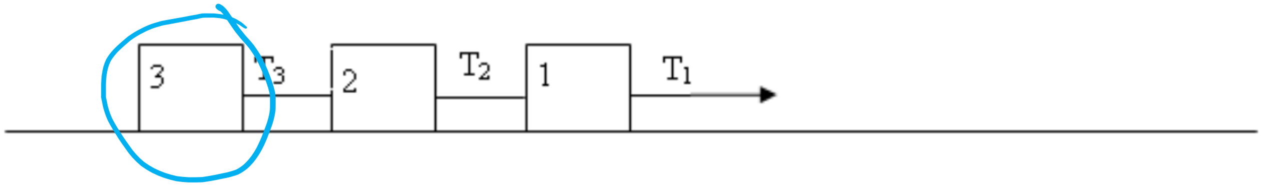
B. $F_1 > F_3$

C. $F_1 < F_3$



Question 1

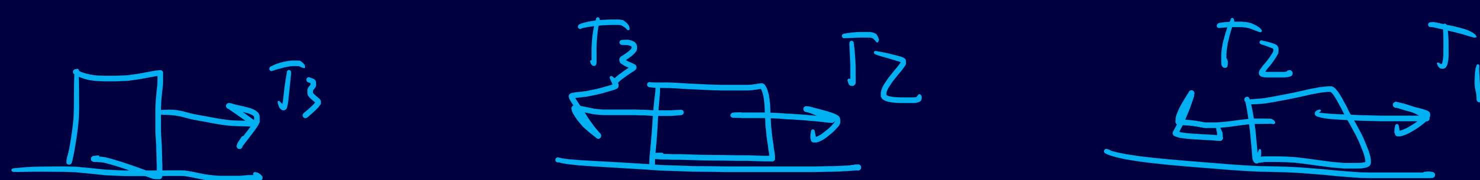
Three boxes of equal mass, *m*, are connected to one another by strings as shown in the figure. They are pulled across a frictionless surface by tension T_1.



Which of the three boxes has the largest net force acting on it?

- A ☐ box 1
- B ☐ box 2
- C ☐ box 3
- D ☐ boxes 1 and 3
- E ☐ All three boxes have the same net force acting on them.

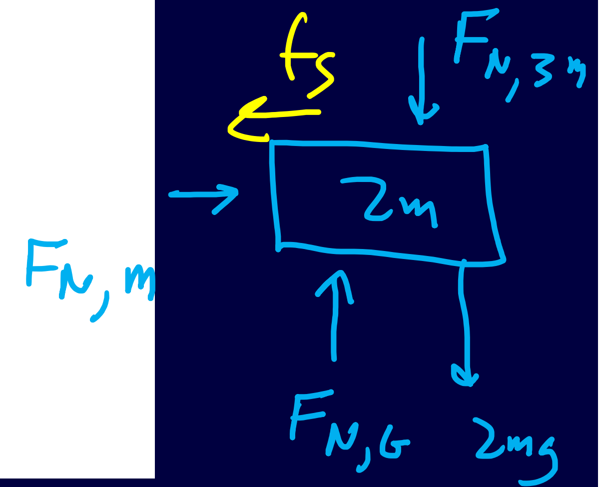
$$\sum F = ma$$



PART A [6 points]

Three blocks are placed in contact on a horizontal frictionless surface. A constant force of magnitude F is applied to the box of mass M. There is friction between the surfaces of blocks $2M$ and $3M$ ($\mu_s = 0.20$, $\mu_k = 0.15$) such that the three blocks accelerate together to the right. (a) Sketch a Free-Body diagram for the block of mass 2M. (b) What is the acceleration of the blocks? (You may assume block $3M$ does not slide or fall off block $2M$.) (c) What is the maximum force F that can be applied, before the $3M$ block slides off?

M=7 Kg
F = 28 N



How many forces act on the block of 2m?

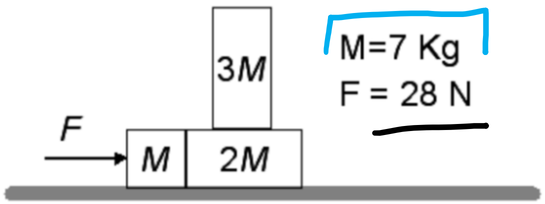
A) 5
B) 4
C) 3
D) 2
E) 6

Friction

A) →
B) ←

PART A [6 points]

Three blocks are placed in contact on a horizontal frictionless surface. A constant force of magnitude F is applied to the box of mass M. There is friction between the surfaces of blocks $2M$ and $3M$ ($\mu_s = 0.20$, $\mu_k = 0.15$) such that the three blocks accelerate together to the right. (a) Sketch a Free-Body diagram for the block of mass 2M. (b) What is the acceleration of the blocks? (You may assume block $3M$ does not slide or fall off block $2M$.) (c) What is the maximum force F that can be applied, before the $3M$ block slides off?



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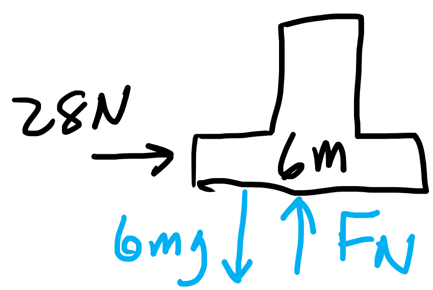


$\Sigma F_x = m a_x$

$28N = 6m\,a$

$a = \frac{28N}{6m}$

$= 0.67\ m/s^2$

What is the acceleration of the blocks?

a) 2.3 m/s²

b) 4.0 m/s²

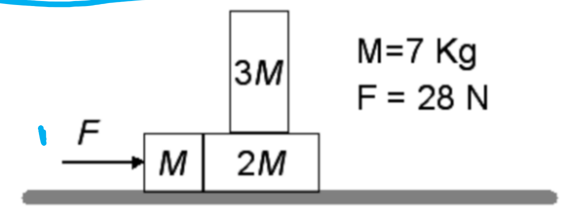
c) 0.67 m/s²

d) 6.1 m/s²

e) 0.34 m/s²

PART A [6 points]

Three blocks are placed in contact on a horizontal frictionless surface. A constant force of magnitude F is applied to the box of mass M. There is friction between the surfaces of blocks $2M$ and $3M$ ($\mu_s = 0.20$, $\mu_k = 0.15$) such that the three blocks accelerate together to the right. (a) Sketch a Free-Body diagram for the block of mass 2M. (b) What is the acceleration of the blocks? (You may assume block $3M$ does not slide or fall off block $2M$.) (c) What is the maximum force F that can be applied, before the $3M$ block slides off?

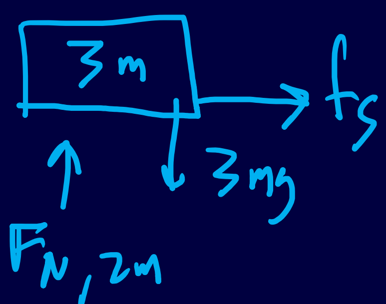


M=7 Kg

F = 28 N

$a_{max} = \mu g$

$= 1.962\ m/s^2$



$\Sigma F_y = 0$

$F_{N,2m} = 3mg$

$\Sigma F_x = 3ma$

$f_s^{max} = 3ma$

$\mu_s F_{N,2m} = 3ma$

$\mu_s 3mg = 3ma$

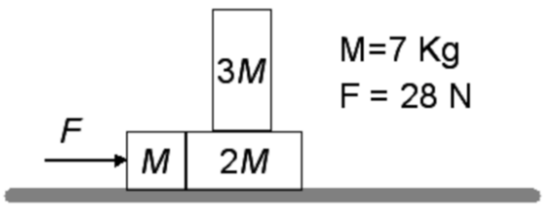
$F_{max} = 6m\,a$

$= 6m(1.962\ m/s^2)$

$= 82.32\,N$

PART A [6 points]

Three blocks are placed in contact on a horizontal frictionless surface. A constant force of magnitude *F* is applied to the box of mass *M*. There is friction between the surfaces of blocks 2*M* and 3*M* ($\mu_s = 0.20$, $\mu_k = 0.15$) such that the three blocks accelerate together to the right. (a) Sketch a Free-Body diagram for the block of mass 2M. (b) What is the acceleration of the blocks? (You may assume block 3*M* does not slide or fall off block 2*M*.) (c) What is the maximum force *F* that can be applied, before the 3*M* block slides off?



M=7 Kg

F = 28 N

[redacted]

$\Sigma F_x = ma$

$\Sigma F_y = 0$

$-f_k = -\mu_k F_N = -\mu_k mg$

$F_N = mg$

Clicker Question 6:

A box slides along a track with elevated ends and a flat central part as in the figure below. The flat part has a length of L = 2.0 m. For the flat central part, the coefficient of kinetic friction is μk = 0.20. Please assume the rest of the track is frictionless. The box is released from rest at a height H = 1.0 m above the flat part of the track. (a) [4 points] At what height h will the box reach on the other side of the track after passing through the flat central part one time? (b) [2 points] Where will the box finally come to rest?

How much energy is lost after the box travels past the flat central part once?

$W = Fd = \mu mgL$

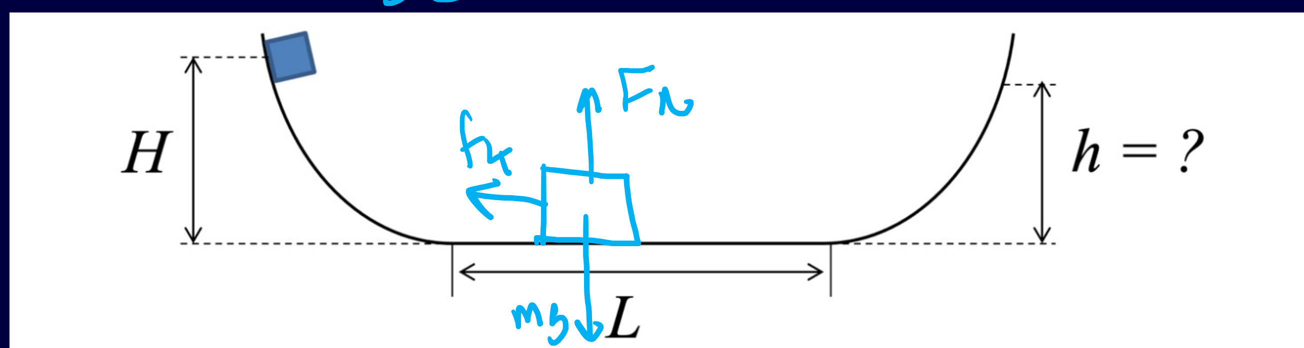
A. mgH

B. mgh

C. mgL

D. μmgL

E. μmgh



$$mgH - \mu mgL = mgh$$

$$H - \mu L = h$$

$$h = H - \mu L$$

$$= 1\,m - 0{,}20(2m) = 0{,}6\,m$$

$$W_{NC} = E_f - E_i$$

$$-\mu mgL = mgh - mgH$$

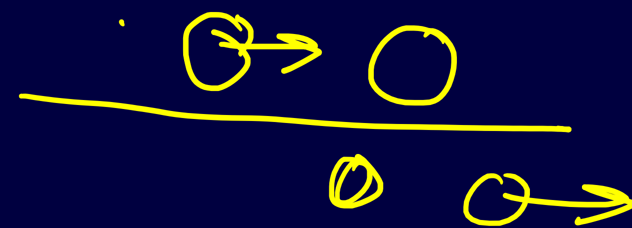
$$mgH - \mu mgL = mgh$$

Clicker Question 7:

There are two identical carts (with the same mass) on a frictionless straight horizontal track. Cart B is initially stationary, and cart A collides into cart B. Can A reverse its direction of motion after the collision?

No spin

$\frac{1}{2} m v^2$



(A) No, never.

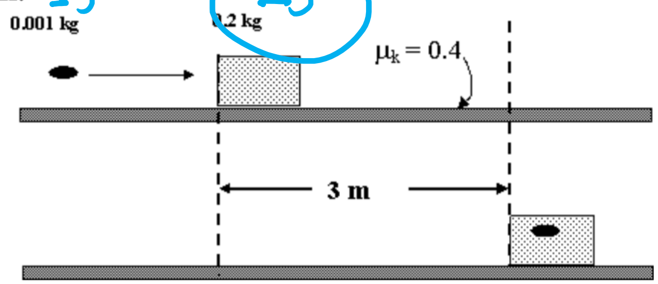
(B) Yes.

(C) It depends on the details of the collision.

$\frac{1}{2} m (2v)^2 + \frac{1}{2} m v^2$

Question 3

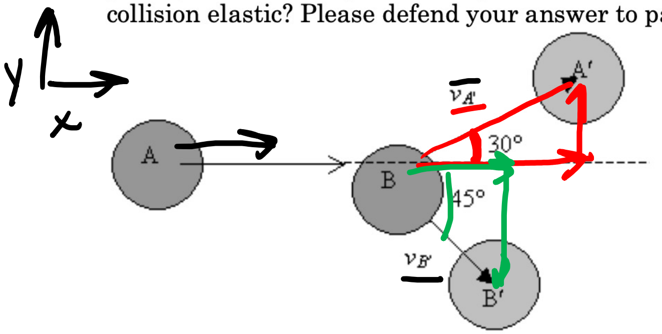
A 0.001 kg bullet is fired from a gun and lodges inside a wooden block of mass 0.2 kg. The block and bullet then slide on a rough floor with a coefficient of kinetic friction $\mu_k = 0.4$ before coming to rest after sliding a distance of 3 m.



Compare KE_i, the initial kinetic energy of the bullet, with W_f, the work done by the frictional force between the block and the floor in stopping the block.

- ☐ $KE_i < W_f$
- ☐ $KE_i = W_f$
- ☒ $KE_i > W_f$

PART A [6 points]
On a smooth, frictionless, ice surface a hockey puck (A in the figure) moving at a speed of v_A = 30 m/s strikes an identical puck (B) which is initially at rest. The pucks move off at different angles with respect to the original direction of motion of puck A, as shown in the diagram. (The positions of the pucks at a time after the collision are shown as A′ and B′, and their directions of motion are indicated.) (a) [4 points] What is the speed of the pucks after the collision? (b) [2 points] Was this collision elastic? Please defend your answer to part (b).



No external forces in x-y axis

P_x: $m v_A = m v_{A'} \cos 30 + m v_{B'} \cos 45$

P_y: $0 = m v_{A'} \sin 30 - m v_{B'} \sin 45$

$v_{A'} = v_{B'} \dfrac{\sin 45}{\sin 30} = 1.41\, v_{B'} = 21.9 \text{ m/s}$

$v_A = v_{A'} \cos 30 + v_{B'} \cos 45$

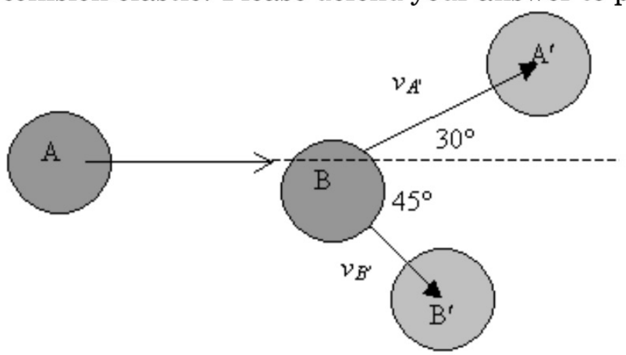
$v_A = 1.41\, v_{B'} \cos 30 + v_{B'} \cos 45$

$v_A = v_{B'} (1.41 \cos 30 + \cos 45)$

$v_{B'} = \dfrac{v_A}{1.41 \cos 30 + \cos 45}$

$= 15.55 \text{ m/s}$

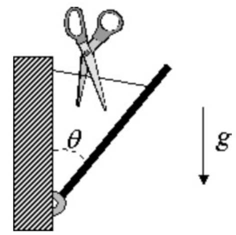
PART A [6 points]
On a smooth, frictionless, ice surface a hockey puck (A in the figure) moving at a speed of $v_A = 30$ m/s strikes an identical puck (B) which is initially at rest. The pucks move off at different angles with respect to the original direction of motion of puck A, as shown in the diagram. (The positions of the pucks at a time after the collision are shown as A/ and B/, and their directions of motion are indicated.) (a) [4 points] What is the speed of the pucks after the collision? (b) [2 points] Was this collision elastic? Please defend your answer to part (b).



[redacted]

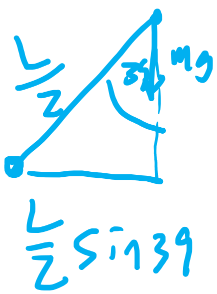
Question 3

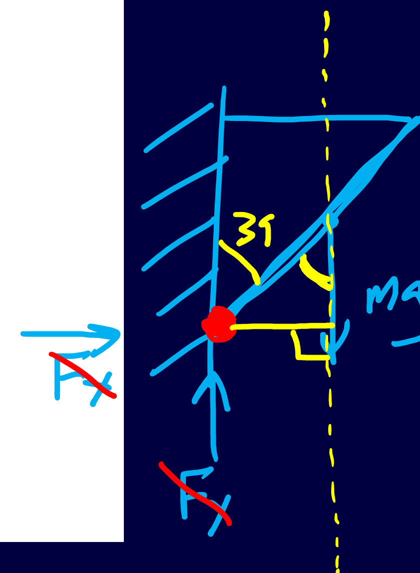
A uniform rod of mass $M = 2$ kg and length $L = 1.5$ m is attached to a wall with a frictionless pivot and a string as shown in the diagram above. The initial angle θ of the rod with respect to the wall is 39°. The string is then cut. The moment of inertia of a rod about an axis through one end is $ML^2/3$.



What is the angular acceleration α of the rod immediately after the string is cut?

- ☐ $\alpha = 1.75$ rad/s^2
- ☐ $\alpha = 3.09$ rad/s^2
- ☐ $\alpha = 4.92$ rad/s^2
- ☒ $\alpha = 6.17$ rad/s^2
- ☐ $\alpha = 7.84$ rad/s^2





$$\Sigma \tau = I\alpha$$

$$mg\left(\frac{L}{2}\sin 39\right) = \frac{1}{3} mL^2 \alpha$$

$$L = 1.5\text{ m}$$

$$\alpha = \frac{\frac{g}{2}\sin 39}{\frac{1}{3}L} = 6.17\ \frac{\text{rad}}{\text{s}^2}$$

PART B [6 points]

A fly of mass 2 g (.002 kg - it's a big fly), viewed from above, begins to walk counter-clockwise on a turntable of mass 0.5 kg. The turntable is a solid, uniform cylinder of radius 0.2 m that turns without friction about its center, and the fly is situated half way between the center and the outer radius of the cylinder. The fly and the turntable are initially at rest. (a) [4 points] If the fly's speed is .005 m/s in its circular path (relative to the ground), what is the magnitude of the angular velocity of the turntable? (b) [2 points] Now the fly stops walking. After the fly has stopped, what will happen to the turntable? Will it be rotating? If so, in what direction?

What direction will the turntable rotate?

A) CW

B) CCW

PART B [6 points]

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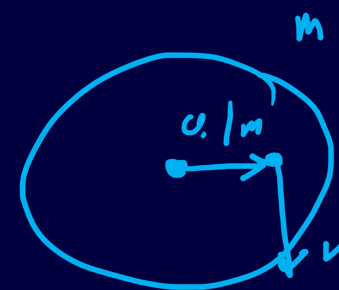

point mass

What is the moment of inertia for the fly?

a) 1×10^{-5} kgm²

b) 4×10^{-5} kgm²

c) 5×10^{-5} kgm²

d) 2×10^{-5} kgm²

e) 1×10^{-4} kgm²

$I = \sum m r^2$

$I = m r^2$

$= (0.002\text{ kg})(0.1\text{ m})^2$

$= 2\times10^{-5}\text{ kgm}^2$

PART B [6 points]
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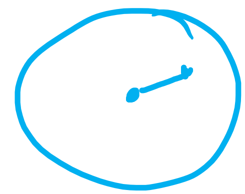


$v = \omega r$

$\omega = \frac{v}{r_{1/2}}$

$=$

$L_i = L_f$

$0 = I_{fly}\omega_{fly} + I_T \omega$

$= I_{fly}\frac{v}{r_{1/2}} + \frac{1}{2}mr^2\omega$

$-I_{fly}\frac{v}{r_{1/2}} = \frac{1}{2}mr^2\omega$

$\omega = \frac{-I_{fly}\frac{v}{r_{1/2}}}{\frac{1}{2}mr^2}$

$= \frac{(2\times10^{-5}\ kg\,m^2)\frac{0.005\ m/s}{0.1\ m}}{\frac{1}{2}\,0.5\ kg\ 0.2\ m^2} = -1\times10^{-4}\ \frac{rad}{s}$

CW

Clicker Question 8:

A flat plate P of mass 5.0 kg is attached to a spring of spring constant k = 60 N/m and executes horizontal simple harmonic motion by sliding across a frictionless surface. A block B of mass 2.0 kg rests on the plate and the coefficient of static friction between the block and the plate is μ= 0.60. What is the maximum amplitude of oscillation that the plate-block system can have in order that the block not slip on the plate?

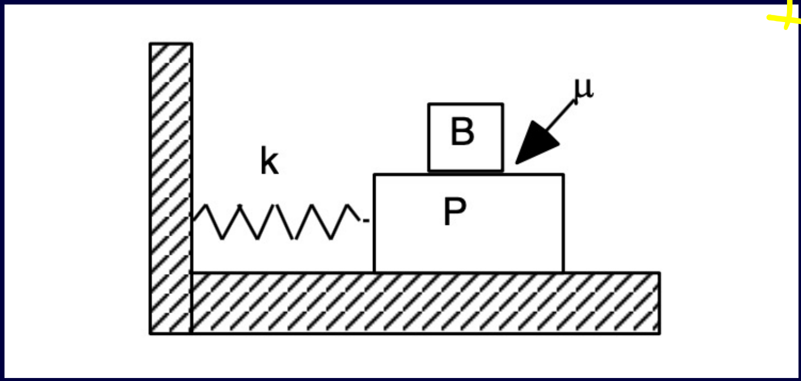
A. 0.44 m

B. 0.57 m

C. 0.69 m

D. 2.12 m

E. 1.12 m



$F_N = mg$

Old: $\Sigma F = ma$

$f_s^{max} = ma$

$\mu_s F_N$

$\mu_s mg = ma$

$a_{max} = \mu g$

$a_{max} = \omega^2 A$

$\mu g = \omega^2 A$

$A = \frac{\mu g}{\omega^2} = \frac{\mu m g}{k}$

$= \frac{(0.60)\, 7\,kg\; 9.81\, m/s^2}{60\, N/m} = 0.69\, m$

$$\omega^2 = \frac{k}{m} = \frac{60\,\mathrm{N/m}}{7\,\mathrm{kg}}$$