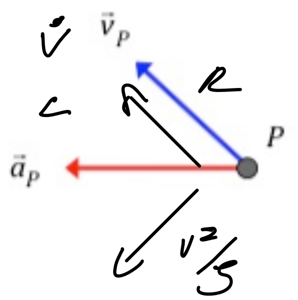
Q1 Path Description of Particle Kinematics

4 Points

You are traveling in a forward-moving automobile P, with the velocity and acceleration vectors for point P being shown in the figure as $\vec{v}_P$ and $\vec{a}_P$, respectively. Choose the response below that most accurately describes your motion:

- You are speeding up and turning left.
- You are speeding up and turning right.
- You are slowing down and turning left.
- You are slowing down and turning right.
- You are traveling on a straight path with a constant speed.
- None of the above.



$\dot{v}\hat{e}_t$ points in same direction as $\vec{v}_p$

$v^2/\rho\ \hat{e}_n$ points toward left

Q2 Chain rule of differentiation

4 Points

You are traveling in a forward-moving automobile P, with the velocity and acceleration vectors for point P being shown in the figure as $\vec{v}_P$ and $\vec{a}_P$, respectively. Choose the response below that most accurately describes your motion:

You are speeding up and turning left.

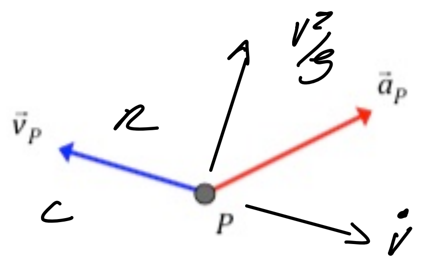
You are speeding up and turning right.

You are slowing down and turning left.

You are slowing down and turning right.

You are traveling on a straight path with a constant speed.

None of the above.



$\dot{v}\hat{e}_t$ points opposite of $\vec{v}_P$

$\frac{v^2}{\rho}\hat{e}_n$ points to the right

Q3

4 Points

Particle P is traveling in the xy-plane on a path described by $y = x^2 + 2x$, where x and y are in ft. The x-component of velocity is known to have a $constant$ value of 2 ft/s. Choose the response below that most accurately describes the value of $\ddot{y}$ at x = 0.

- $\ddot{y}$ = -2 ft/s^2
- $\ddot{y}$ = 0
- $\ddot{y}$ = 2 ft/s^2
- $\ddot{y}$ = 4 ft/s^2
- $\ddot{y}$ = 8 ft/s^2
- None of the above.

$y = x^2 + 2x$

$$\frac{dy}{dt} = \frac{d}{dt}(x^2) + 2\frac{dx}{dt} = 2x\frac{dx}{dt} + 2\,dx/dt = 2x\dot{x} + 2\dot{x}$$

$\dot{y} = 2x\dot{x} + 2\dot{x}$

$$\frac{d\dot{y}}{dt} = \ddot{y} = \frac{2\,d(x\dot{x})}{dt} + \frac{2\,d(\dot{x})}{dt} = 2\cancelto{2}{\dot{x}}\cancelto{2}{\dot{x}} + 2\cancelto{0}{x}\cancelto{0}{\ddot{x}} + 2\cancelto{0}{\ddot{x}}$$

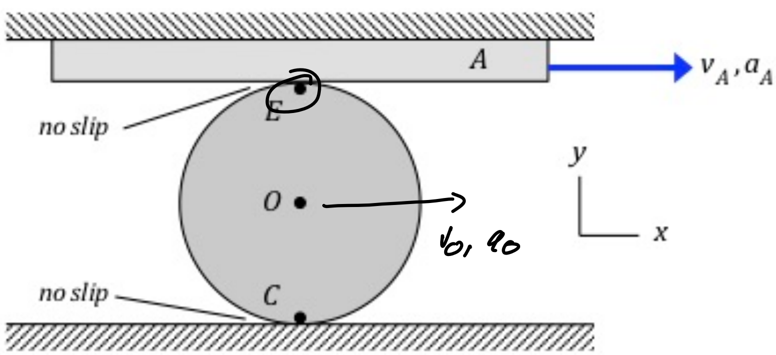
$\ddot{y} = 8\,ft/s^2$

Q1 Rolling without slipping

4 Points

Bar A moves to the right with a speed of v_A and is accelerating to the right at a rate of $\vec{a}_A$. The disk shown in the figure does not slip at either its contact point E or contact point C. If the acceleration of C is written as $\vec{a}_C = a_{Cx}\hat{i} + a_{Cy}\hat{j}$, choose the response below that most accurately describes the xy-components of this vector:

- $a_{Cx} > 0$ and $a_{Cy} > 0$
- $a_{Cx} > 0$ and $a_{Cy} = 0$
- $a_{Cx} = 0$ and $a_{Cy} > 0$
- $a_{Cx} = a_{Cy} = 0$
- $a_{Cx} < 0$ and $a_{Cy} < 0$
- $a_{Cx} < 0$ and $a_{Cy} = 0$
- $a_{Cx} = 0$ and $a_{Cy} < 0$



$$\bar{a}_O = a_O\hat{i} = \bar{a}_C + \bar{\alpha}\times\bar{r}_{O/C} - \omega^2\bar{r}_{O/C}$$

$$a_O\hat{i} = 0\hat{i} + a_{Cy}\hat{j} + \alpha k \times R\hat{j} - \omega^2 R\hat{j}$$

$$a_O\hat{i} = a_{Cy}\hat{j} - \alpha R\hat{i} - \omega^2 R\hat{j}$$

i: $a_O = -\alpha R$

j: $0 = a_{Cy} - \omega^2 R$ $\quad a_{Cy} = \omega^2 R$

Q2 Acceleration

4 Points

Bar OA rotates about the fixed pin O with a $constant$ angular velocity of $\vec{\omega}$. Choose the response below that most accurately represents the acceleration of point A on the bar.

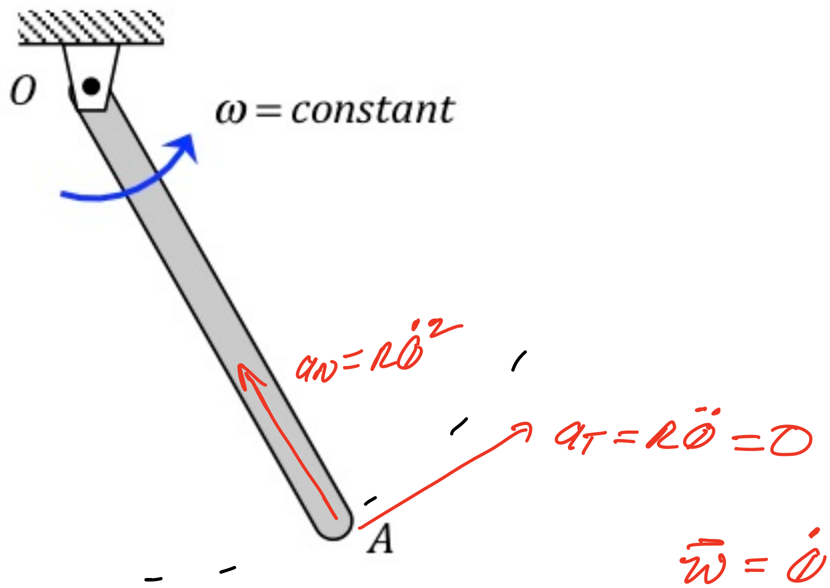


Figure (a)

Figure (b)

Figure (c)

Figure (d)

Figure (e)

Figure (f)

$\vec{a}_A = \vec{0}$

None of the above.

Figure (a)

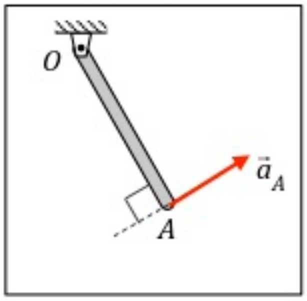


Figure (b)

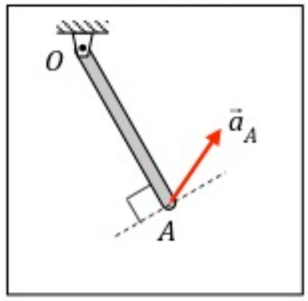


Figure (c)

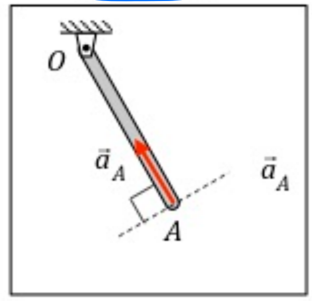


Figure (d)

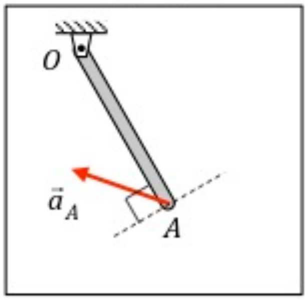


Figure (e)

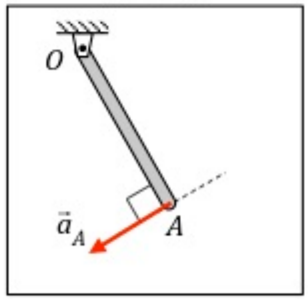
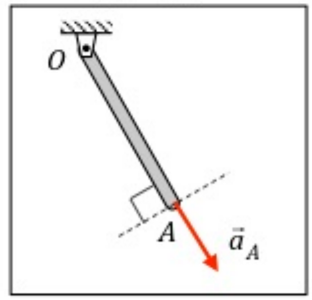


Figure (f)



Q3 Position vectors

4 Points

The mechanism shown is made up on links OA, AB and BE. Choose the response below that most accurately describes the vector $\vec{r}_{B/A}$:

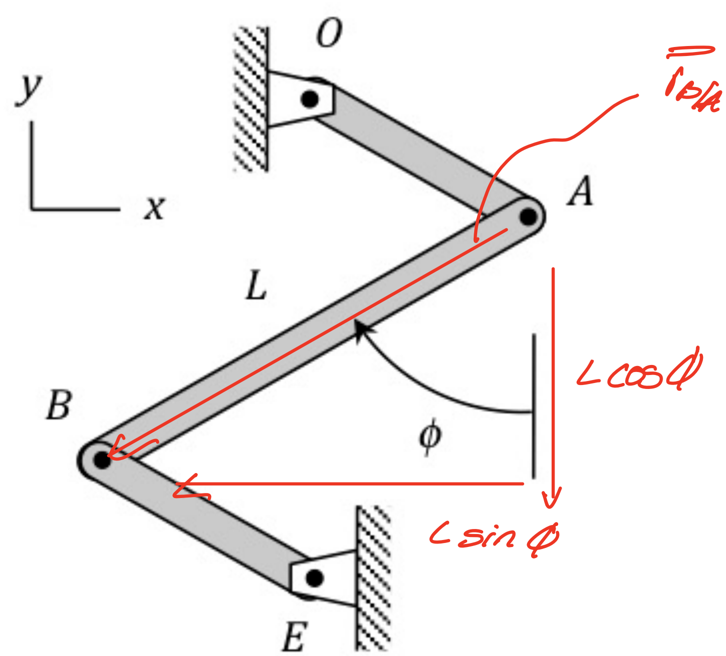
$\vec{r}_{B/A} = Lsin\phi\hat{i} + Lcos\phi\hat{j}$

$\vec{r}_{B/A} = Lsin\phi\hat{i} - Lcos\phi\hat{j}$

$\vec{r}_{B/A} = -Lsin\phi\hat{i} + Lcos\phi\hat{j}$

$\vec{r}_{B/A} = -Lsin\phi\hat{i} - Lcos\phi\hat{j}$

None of the above.



$\vec{r}_{B/A} = -L\sin\phi\,\hat{i} - L\cos\phi\,\hat{j}$

Q4 Word of the day

4 Points

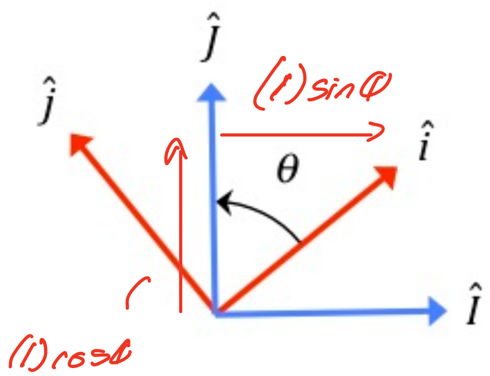
Type in the "word of the day". (See the top of page 106 of your lecture book.) This text answer is NOT case sensitive.

instant center

Q1 Coordinate transformations

8 Points

Two sets of Cartesian coordinate axes with unit vectors of $\hat{i}$ and $\hat{j}$, and $\hat{I}$ and $\hat{J}$ are shown below.



$\hat{i} = + \sin\theta \hat{I} + \cos\theta \hat{J}$

Q1.1

4 Points

Choose the response below that most accurately represents the unit vector $\hat{i}$ in terms of the unit vectors $\hat{I}$ and $\hat{J}$:

$\hat{i} = sin\theta\hat{I} + cos\theta\hat{J}$

$\hat{i} = cos\theta\hat{I} + sin\theta\hat{J}$

$\hat{i} = cos\theta\hat{I} - sin\theta\hat{J}$

$\hat{i} = -sin\theta\hat{I} + cos\theta\hat{J}$

none of the above

Q1.2
4 Points

Choose the response below that most accurately represents the unit vector $\hat{I}$ in terms of the unit vectors $\hat{i}$ and $\hat{j}$:

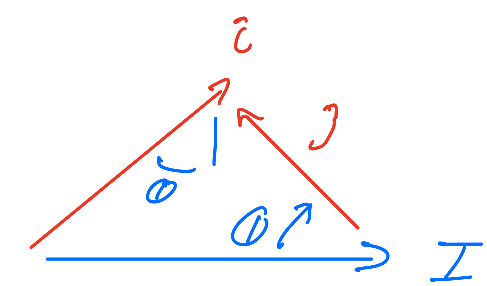
$\hat{I} = sin\theta\hat{i} + cos\theta\hat{j}$

$\hat{I} = cos\theta\hat{i} + sin\theta\hat{j}$

$\hat{I} = cos\theta\hat{i} - sin\theta\hat{j}$

$\hat{I} = sin\theta\hat{i} - cos\theta\hat{j}$

none of the above



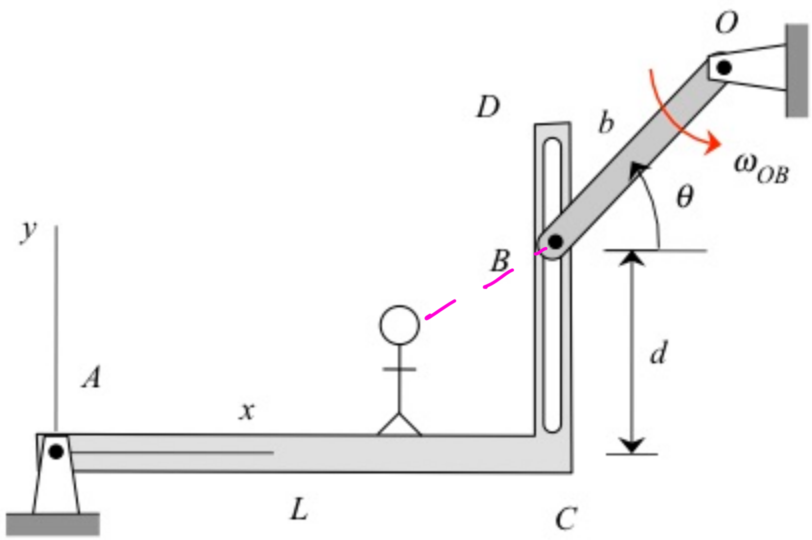
$\hat{I} = {}'' + ''\ \hat{j} \qquad '' - ''\ \hat{j}$

$= sin\theta\,\hat{i} - cos\theta\,\hat{j}$

Q2 Observed velocity

4 Points

Link OB rotates CCW with a rate of ω_{OB}. End B of OB is constrained to move within a slot in a second link AD. An observer is attached to link AD. Choose the response below that correctly describes the velocity of B as seen by the observer on link AD:



$\left(\vec{v}_{B/A}\right)_{rel} = -b\omega_{OB}\hat{j}$

$\left(\vec{v}_{B/A}\right)_{rel} = b\omega_{OB}\hat{i}$

$\left(\vec{v}_{B/A}\right)_{rel} = \dot{d}\hat{j}$

$\left(\vec{v}_{B/A}\right)_{rel} = 0$

$\left(\vec{v}_{B/A}\right)_{rel} = b\omega_{OB}\left(sin\theta\hat{i} - cos\theta\hat{j}\right)$

$\left(\vec{v}_{B/A}\right)_{rel} = b\omega_{OB}\left(cos\theta\hat{i} - sin\theta\hat{j}\right)$

None of the above.

Q3
4 Points

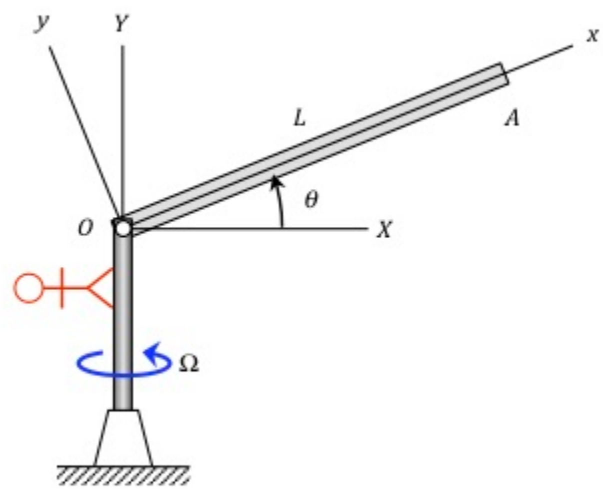
On page 163 what is the last word in the Given statement. Your response is NOT case sensitive.

fixed

Q1 MRF question - Observer #1

8 Points

A shaft rotates about a fixed, vertical axis with a constant rate of Ω. Arm OA is pinned to the rotating shaft, with the arm being raised at a constant rate of $\dot{\theta}$. An observer is attached to the rotating shaft, as shown in the figure.



Q1.1 Angular acceleration

4 Points

Indicate the response below that most accurately describes the angular acceleration α of the observer when $\theta = 0$:

$\alpha = \vec{0}$

$\alpha = \Omega^2 \hat{j}$

$\alpha = \dot{\theta}^2 \hat{k}$

$\alpha = \Omega \dot{\theta} \hat{i}$

$\alpha = \Omega \dot{\theta} \hat{j}$

$\alpha = \Omega \dot{\theta} \hat{k}$

None of the above

$\vec{\omega}_{obs} = \Omega \hat{J}$ both are constant

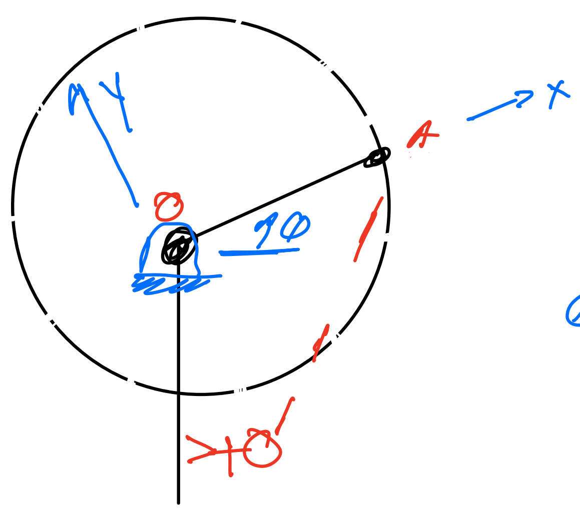
$\vec{\alpha} = \vec{0}$

Q1.2 Relative acceleration
4 Points

Indicate the response below that most accurately describes the acceleration of point A as seen by the observer $\left(\vec{a}_{A/O}\right)_{rel}$ when $\theta = 0$
:

- $\left(\vec{a}_{A/O}\right)_{rel} = \vec{0}$
- $\left(\vec{a}_{A/O}\right)_{rel} = -L\Omega^2\hat{i}$
- $\left(\vec{a}_{A/O}\right)_{rel} = -L\Omega^2\hat{j}$
- $\left(\vec{a}_{A/O}\right)_{rel} = -L\dot{\theta}^2\hat{i}$
- $\left(\vec{a}_{A/O}\right)_{rel} = -L\dot{\theta}^2\hat{j}$
- $\left(\vec{a}_{A/O}\right)_{rel} = -L\Omega\dot{\theta}\hat{i}$
- $\left(\vec{a}_{A/O}\right)_{rel} = -L\Omega\dot{\theta}\hat{j}$
- None of the above

What he sees



$\dot{\theta}$ = constant

$$\vec{a}_{A/O})_{rel} = \cancel{\vec{a}_O)_{rel}}^{0} + \cancel{\vec{\alpha}_{OA})_{rel}}^{0} \times \vec{r}_{A/O} - \vec{\omega}_{OA}^2)_{rel}\,\vec{r}_{A/O}$$

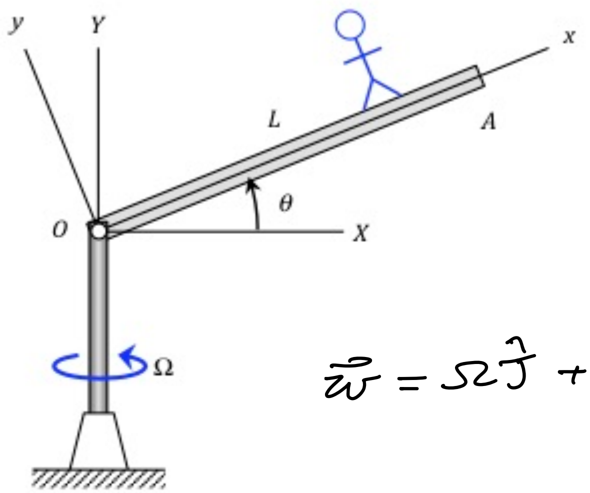
From his viewpoint

$$= -\vec{\omega}_{OA}^2)_{rel}\,\vec{r}_{A/O} = -\dot{\theta}^2 L\,\hat{i}$$

Q2 MRF question - Observer #2

8 Points

Same problem as above EXCEPT the observer is now on arm OA, as shown in the figure below.



$\vec{\omega} = \Omega\hat{j} + \dot{\theta}\hat{k}$

Q2.1 Angular acceleration

4 Points

Indicate the response below that most accurately describes the angular acceleration α of the observer when $\theta = 0$:

- $\alpha = \vec{0}$
- $\alpha = \Omega^2\hat{j}$
- $\alpha = \dot{\theta}^2\hat{k}$
- $\alpha = \Omega\dot{\theta}\hat{i}$
- $\alpha = \Omega\dot{\theta}\hat{j}$
- $\alpha = \Omega\dot{\theta}\hat{k}$
- None of the above

$\vec{\alpha} = \dot{\vec{\omega}}$

$= \cancel{\dot{\Omega}\hat{j}}^{0} + \cancel{\Omega\dot{\hat{j}}}^{0} + \cancel{\ddot{\theta}\hat{k}}^{0} + \dot{\theta}\dot{\hat{k}}$

$= \dot{\theta}\dot{\hat{k}} = \dot{\theta}(\vec{\omega} \times \hat{k})$

sin 0 = 0 they align

$= \dot{\theta}(\cancel{\Omega\hat{j}}^{\hat{i}} + \dot{\theta}\hat{k}) \times \hat{k}$

$= \dot{\theta}\Omega\hat{i}$

Q2.2 Relative acceleration
4 Points

Indicate the response below that most accurately describes the acceleration of point A as seen by the observer $\left(\vec{a}_{A/O}\right)_{rel}$ when $\theta = 0$
:

$\left(\vec{a}_{A/O}\right)_{rel} = \vec{0}$

$\left(\vec{a}_{A/O}\right)_{rel} = -L\Omega^2\hat{i}$

$\left(\vec{a}_{A/O}\right)_{rel} = -L\Omega^2\hat{j}$

$\left(\vec{a}_{A/O}\right)_{rel} = -L\dot{\theta}^2\hat{i}$

$\left(\vec{a}_{A/O}\right)_{rel} = -L\dot{\theta}^2\hat{j}$

$\left(\vec{a}_{A/O}\right)_{rel} = -L\Omega\dot{\theta}\hat{i}$

$\left(\vec{a}_{A/O}\right)_{rel} = -L\Omega\dot{\theta}\hat{j}$

None of the above

Q3 Where are you?
1 Point

Indicate the response below that most accurately describes your current location:

I am in room FRNY G140

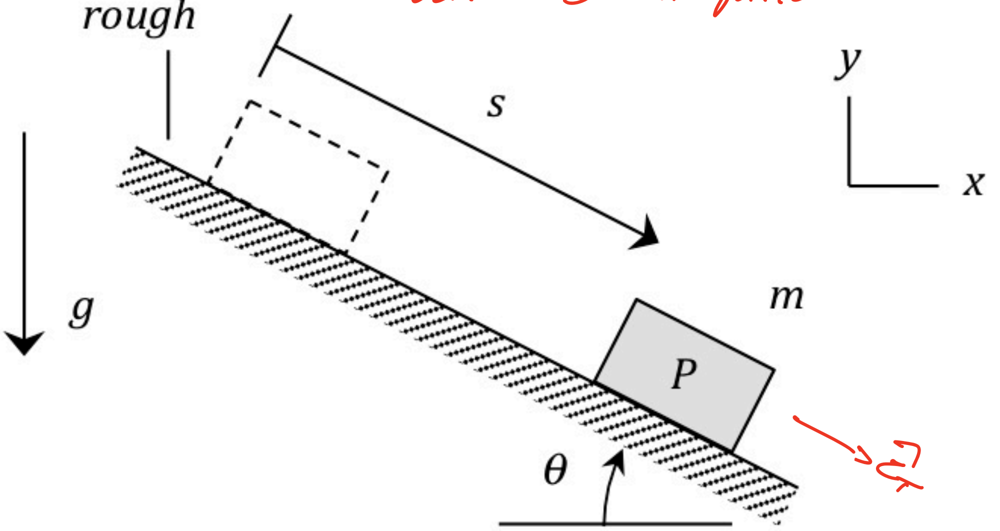
I am NOT in room FRNY G140

Q1 Work due to friction

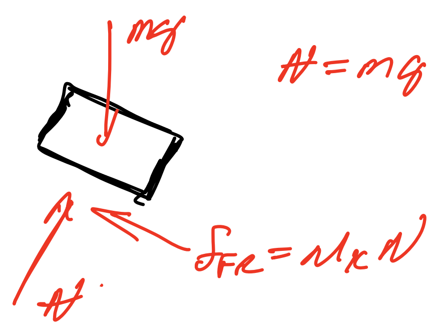
4 Points

Block P slides down through a distance of s a rough incline, where μ_s and μ_k are the static and kinetic coefficients of friction, respectively. Choose the response below that accurately describes the work done by friction on the block, $U^{(f)}_{1\to 2}$.

Work is negative slows down



- $U^{(f)}_{1\to 2} = +\mu_s mgs\cos\theta$
- $U^{(f)}_{1\to 2} = -\mu_s mgs\cos\theta$
- $U^{(f)}_{1\to 2} = +\mu_s mgs$
- $U^{(f)}_{1\to 2} = -\mu_s mgs$
- $U^{(f)}_{1\to 2} = +\mu_k mgs\cos\theta$
- $U^{(f)}_{1\to 2} = -\mu_k mgs\cos\theta$
- none of the above



$N = mg\cos\theta$

$$U_{1-2} = \int \vec{F} \cdot \hat{e}_T \, ds$$

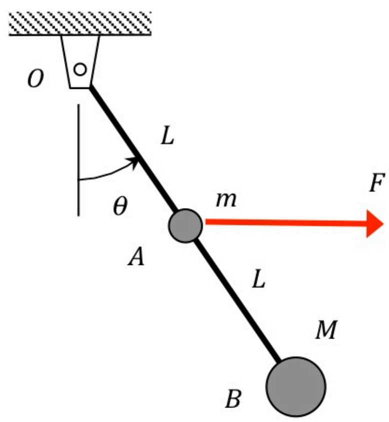
$$= \int -\mu_k mg\cos\theta \, \hat{e}_T \cdot \hat{e}_T \, ds$$

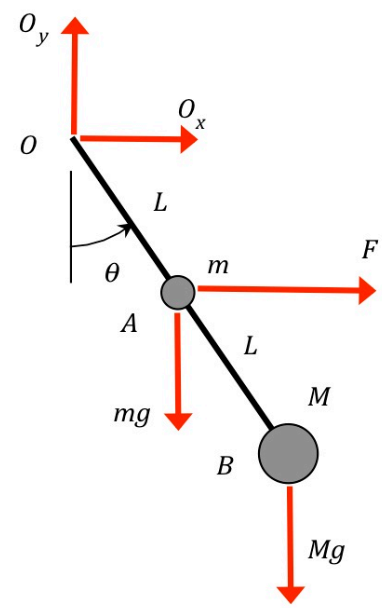
$$= -\mu_k mg\cos\theta \, s$$

Q2 Kinetic energy

4 Points

Particles A and B (having masses of m and M, respectively) are attached to rigid bar OB (with the mass of OB being negligible). A constant, horizontal force F acts to the right on particle A. An FBD of the system made up of A, B and OB is also shown. For the system being released from rest when $\theta = 0$, it is desired to know the speed of particle B as a function of the angle θ. For the system shown, select the correct response below that represents the kinetic energy, T, of the system.





$T = \frac{1}{2} m L^2 \dot{\theta}^2$

$T = \frac{1}{2} M (2L)^2 \dot{\theta}^2$

$T = \frac{1}{2} (m + M) L^2 \dot{\theta}^2$

$T = \frac{1}{2} (m + 4M) L^2 \dot{\theta}^2$

none of the above

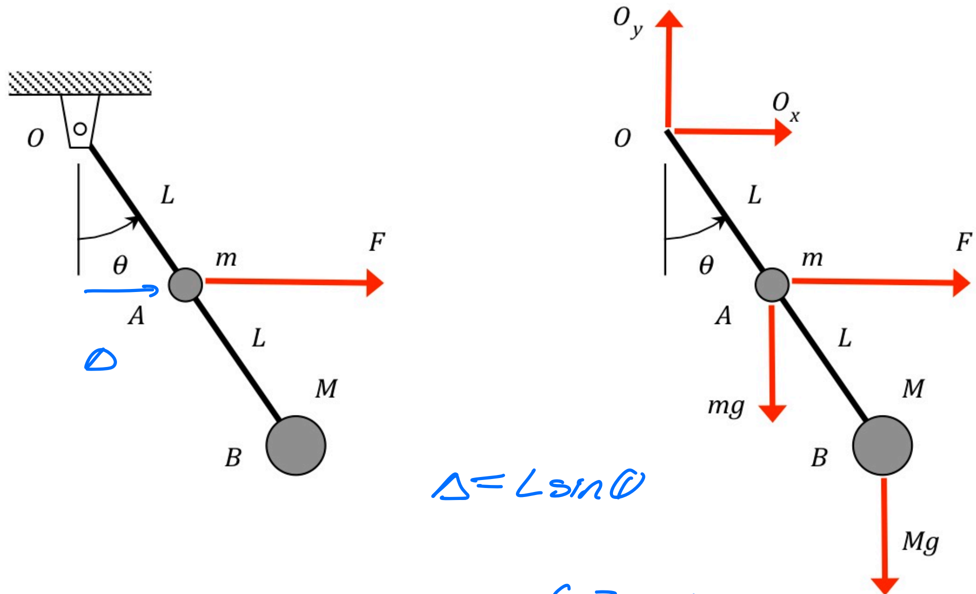
$T = \frac{1}{2} m v_A^2 + \frac{1}{2} M v_B^2$ $\qquad v_A = L\dot{\theta}$ $\qquad v_B = 2L\dot{\theta}$

$= \frac{1}{2} (m + 4M) L^2 \dot{\theta}^2$

Q3 Work due to applied force

4 Points

Same problem as in Question 2. Choose the correct response below that represents the work done by the force F, $U^{(F)}_{1\to2}$, in moving bar OB to an arbitrary angle of $\theta > 0$.



$\Delta = L\sin\theta$

$U_{1-2} = \int \vec{F} \cdot \hat{i}\, ds$
$= FL\sin\theta$

$U^{(F)}_{1\to2} = 0$

$U^{(F)}_{1\to2} = FLsin\theta$

$U^{(F)}_{1\to2} = -FLsin\theta$

$U^{(F)}_{1\to2} = FL\theta$

$U^{(F)}_{1\to2} = -FL\theta$

$U^{(F)}_{1\to2} = 2FLsin\theta$

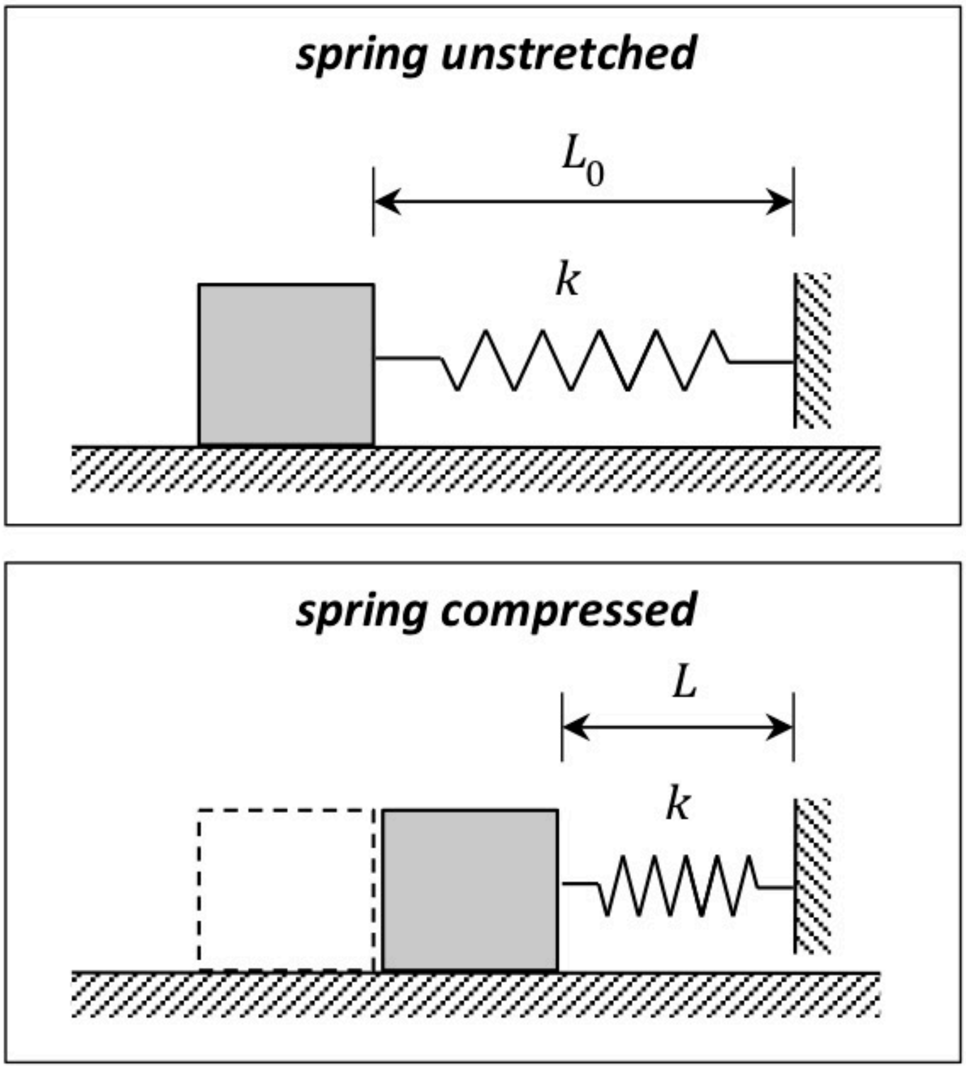
$U^{(F)}_{1\to2} = -2FLsin\theta$

none of the above

Q4 Potential energy in spring

4 Points

A spring of stiffness k and with an unstretched length of L_0 has been compressed to the point that the spring has a length of L, where $L < L_0$. Choose the response below that accurately describes the potential energy, V, of the spring in this compressed state.



$V = 0$

$V = -\frac{1}{2}kL^2$

$V = \frac{1}{2}kL^2$

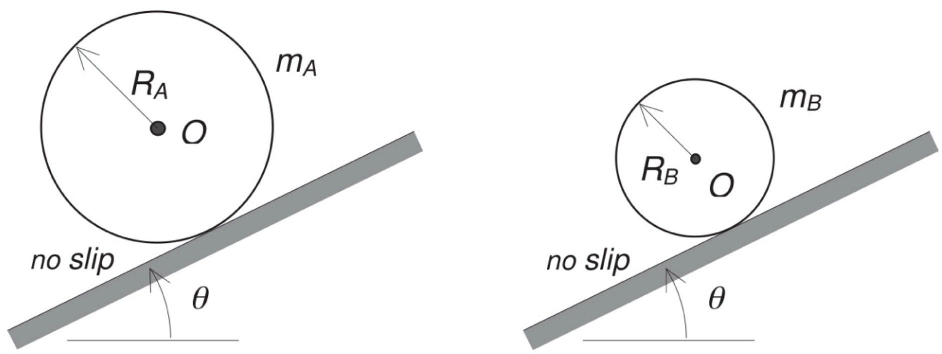
$V = -\frac{1}{2}k\left(L - L_0\right)^2$

$V = \frac{1}{2}k\left(L - L_0\right)^2$

none of the above

Q1
2.5 Points

Consider the homogeneous disks A and B with $m_A > m_B$ and $R_A > R_B$. The disks are released from rest. Circle the answer below that most accurately describes the relatives sizes of the angular accelerations of the centers of the two disk, α_A and α_B on release.

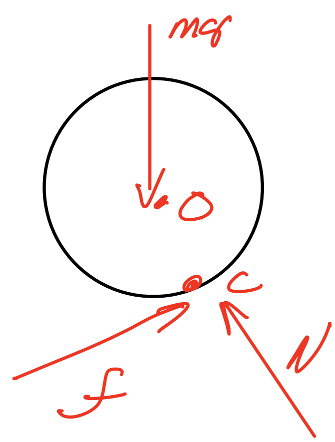


$\alpha_A > \alpha_B$

$\alpha_A = \alpha_B$

$\alpha_A < \alpha_B$

For either mass



$\circlearrowleft \sum M_C: \; mg\sin\theta R = I_C \alpha$

$I_C = \frac{1}{2}mR^2 + mR^2 = \frac{3}{2}mR^2$

$mg\sin\theta R = \frac{3}{2}mR^2 \alpha$

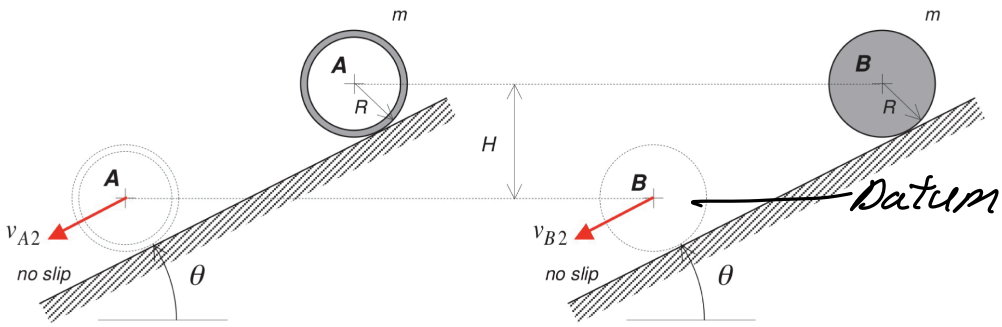
$\alpha = \frac{2}{3}\frac{g}{R}\sin\theta$

$R_A > R_B$

$\alpha \propto \frac{1}{R}$ $\quad \alpha_A < \alpha_B$

Q2 Work Energy
2.5 Points

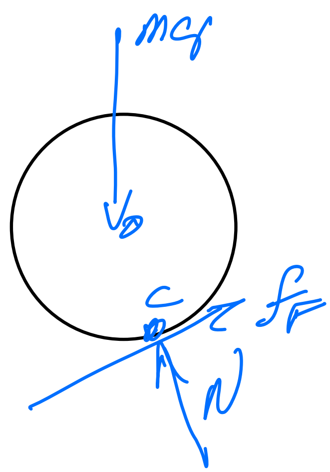
The homogeneous ring and disk are released from rest at the same height. Let v_{A2} and v_{B2} represent the speeds of the centers of the ring and disk after they have dropped through the same vertical distance H. What answer below that most accurately describes the relative sizes of v_{A2} and v_{B2}.



For either

$$T_1 + V_1 + \Sigma U_{1-2}^{NC} = T_2 + V_2$$

- $v_{A2} > v_{B2}$
- $v_{A2} = v_{B2}$
- $v_{A2} < v_{B2}$



$T_1 = 0$

$V_1 = mgH$

$\Sigma U_{1-2}^{NC} = 0$

$T_2 = \frac{1}{2} m v^2 + \frac{1}{2} \bar{I} \omega^2$

$\bar{I} = mR^2$ for Ring

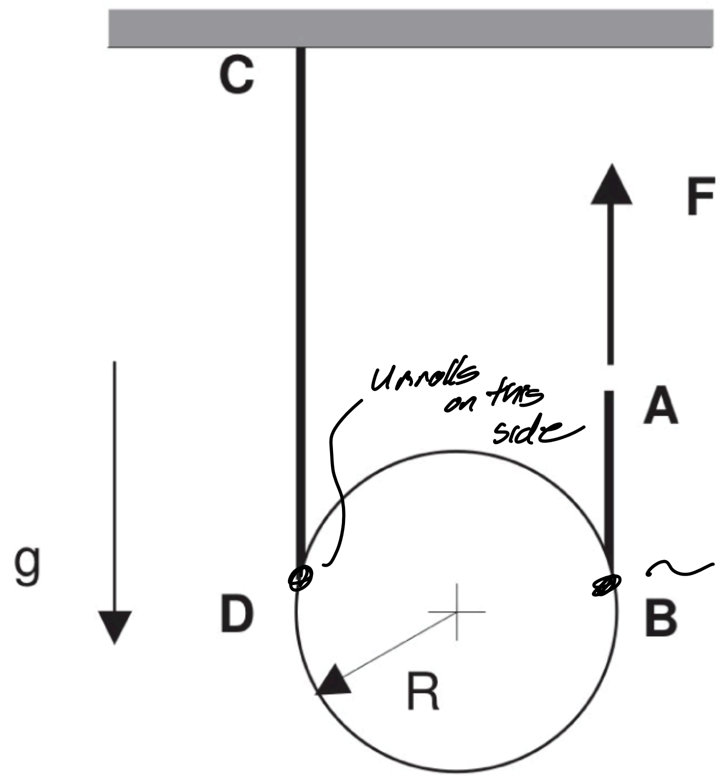
$= \frac{1}{2} mR^2$ for Disk

$v = R\omega$

Q3 Newton and Euler

2.5 Points

The center of the disk shown below is known to have a downward acceleration. Assume that the cable does no slip on the homogenous disk. Circle the answer below that most accurately describes the tension in sections AB and CD of the cable.

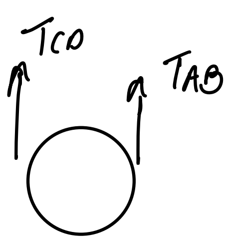


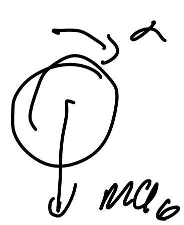
The tension in section AB is smaller than the tension in section CD.

The tension in section AB is equal to the tension in section CD.

The tension in section AB is larger than the tension in section CD.

More information is needed on the problem to answer the question.





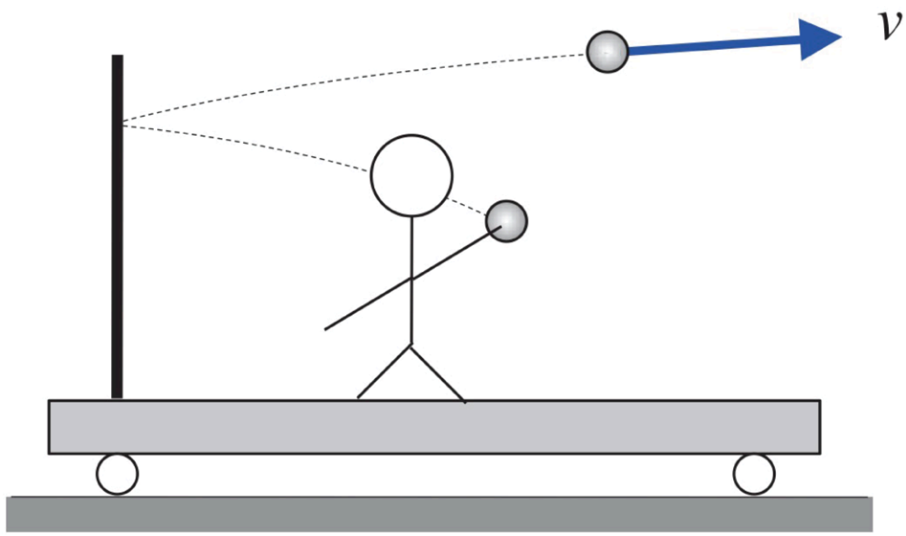
$\curvearrowright T_{CD}R - T_{AB}R > 0$

$I\alpha > 0$

Q4 Impulse Momentum

2.5 Points

You are on a cart that is initially at rest on a smooth track. You throw a ball at a partition that is rigidly mounted on the cart. If the ball bounces off the partition as shown in the figure, then at the instant shown in the figure:

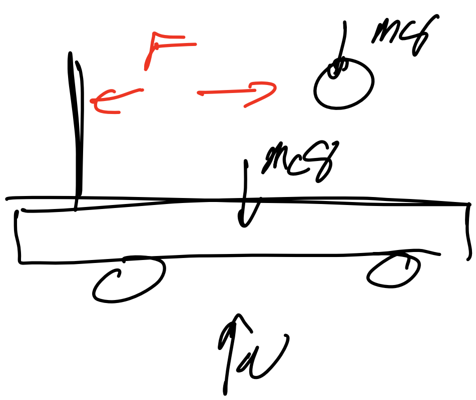


The cart is moving to the right.

The cart is stationary.

The cart is moving to the left.

More information is needed about the impact of the ball with the partition in order to answer this question.



LIM $0 = mV + M_c V_c$

$$V_c = \frac{-mV}{M_c}$$