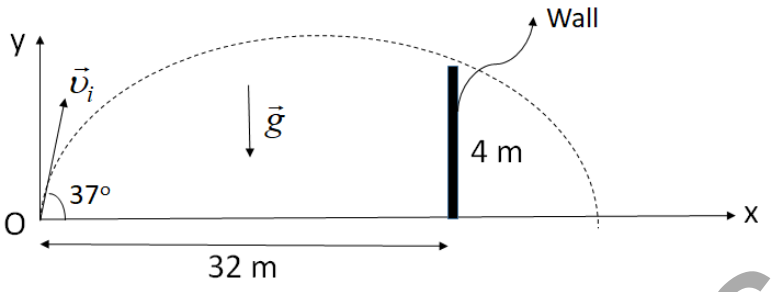
A A A

Name Surname: **Student No:** **Duration: 110 minutes** **11.01.2023**

A small object with mass m=0.5 (kg) is thrown from point O with initial velocity $\vec{\upsilon}_i$ at an angle of θ=37° with the horizontal as shown in the figure. The object hits the ground by passing over a 4 (m) high wall, 32 (m) ahead of the point where it was thrown horizontally. All friction is neglected. Based on this information, answer the following four questions (1-4).



($\sin 37^o$=0.6, $\cos 37^o$=0.8, g=10 (m/s^2))

1) What is the initial velocity of the object in terms of unit vectors in (m/s) unit?

a) $20\hat{i}+16\hat{j}$ b) $12\hat{i}+16\hat{j}$ c) $16\hat{i}+12\hat{j}$ d) $12\hat{i}+20\hat{j}$ e) $3\hat{i}+4\hat{j}$

2) How many seconds after passing the wall does the object hit the ground?

a) 2.4 b) 2 c) 0.8 d) 0.5 e) 0.4

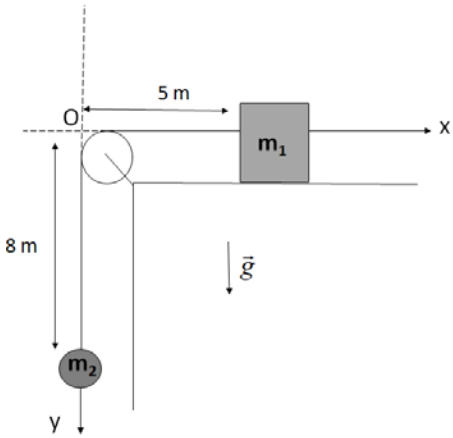
3) What is the angular momentum vector of the object with respect to point O in (kgm^2/s) unit as the object passes through the wall?

a) $96\hat{k}$ b) $-96\hat{k}$ c) $128\hat{k}$ d) $-160\hat{k}$ e) $-128\hat{k}$

4) By accepting the ground level as zero in terms of gravitational potential energy; what is the mechanical energy of the object in (J) unit when it passes right over the wall?

a) 100 b) 120 c) 150 d) 180 e) 240

A block of mass m_1=2 (kg) is connected to a mass of m_2=3 (kg) by a 13 (m) long rope passing through a pulley of negligible mass, as shown in the figure. The system (rope and objects) is released at t=0. All frictions in the system are neglected. According to the xy-coordinate system given in the figure, using this information, answer the following three questions (5-7). (g=10 (m/s^2))



5) For t=1 (s), what is the position vector of the center of mass of the system with respect to O point in terms of unit vectors in (m) unit?

a) $0.8\hat{i}+6.6\hat{j}$ b) $0.4\hat{i}+3.3\hat{j}$ c) $0.8\hat{i}-6.6\hat{j}$

d) $0.4\hat{i}-3.3\hat{j}$ e) $\hat{i}+6.6\hat{j}$

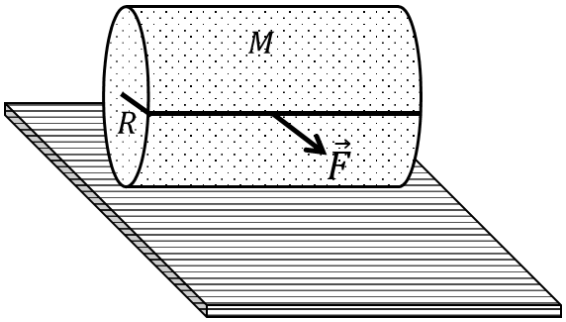
6) For t=1 (s), what is the acceleration vector of the center of mass of the system with respect to O point in terms of unit vectors in (m/s^2) unit?

a) $-6\hat{i}+6\hat{j}$ b) $-4.8\hat{i}+1.8\hat{j}$ c) $4.8\hat{i}-1.8\hat{j}$ d) $2.4\hat{i}-3.6\hat{j}$ e) $-2.4\hat{i}+3.6\hat{j}$

7) What is the net external force acting on the system in terms of unit vectors in (N) unit?

a) $-12\hat{i}+18\hat{j}$ b) $-24\hat{i}+9\hat{j}$ c) $24\hat{i}-9\hat{j}$ d) $12\hat{i}-18\hat{j}$ e) $-30\hat{i}+30\hat{j}$

As shown in the figure, a solid cylinder of mass M and radius R, which is initially at rest, is pulled by a constant horizontal force $\vec{F}$ applied on the rough horizontal surface. The cylinder rolls without slipping. Based on this information, answer the following three questions (8-10).



(The moment of inertia of a solid homogenous cylinder of mass M and radius R about an axis passing through the center of mass and perpendicular to the cylinder is $(I_{CM})_{cylinder} = \frac{1}{2}MR^2$.)

8) What is the acceleration of the center of mass of the cylinder in terms of F and M?

a) $\frac{3F}{2M}$ b) $\frac{3F}{4M}$ c) $\frac{2F}{3M}$ d) $\frac{4F}{3M}$ e) $\frac{F}{3M}$

9) What is the force of friction in terms of F?

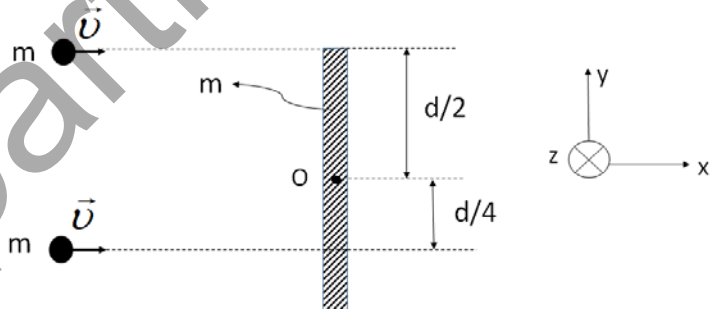
a) $\frac{2F}{3}$ b) $\frac{F}{3}$ c) $\frac{2F}{5}$ d) $\frac{F}{2}$ e) $\frac{F}{4}$

10) For any moment t, what is the magnitude of the angular momentum relative to the cylinder's center of mass in terms of F, R, and t?

a) $\frac{3}{4}FRt$ b) $\frac{1}{2}FRt$ c) $\frac{2}{3}FRt$ d) $\frac{1}{3}FRt$ e) $\frac{1}{4}FRt$

A homogeneous rod of mass m and length d lies along the y-axis on a horizontal frictionless plane as shown in the figure. The rod can rotate freely around the z-axis with a spindle fixed at the center of mass (point O). (The z-axis is directed into the page plane.)Two identical bullets with mass m and velocity $\vec{\upsilon}$ were fired at the same time as in the figure and stuck to the rod. After the collision, there was no shape deformation and no mass loss in the rod and bullets. Based on this information, answer the following two questions (11-12).

(The moment of inertia of a homogeneous solid rod of mass m and length d about an axis passing through the center of mass and perpendicular to the rod is $(I_{CM})_{rod} = \frac{1}{12}md^2$.)



11) What is the ratio of the post-collision kinetic energy of the system to the pre-collision kinetic energy, $\frac{K_{after\ the\ collision}}{K_{before\ the\ collision}}$?

a) $\frac{3}{38}$ b) $\frac{4}{38}$ c) $\frac{6}{38}$ d) $\frac{7}{38}$ e) $\frac{9}{38}$

12) Assuming that the net external torque acting on the system is zero, what are the magnitude and direction of the angular velocity of the system after the collision?

a) $\frac{12}{38}\frac{\upsilon}{d}$, directed into the page plane

b) $\frac{12}{38}\frac{\upsilon}{d}$, directed out of the page plane

c) $\frac{12}{19}\frac{\upsilon}{d}$, directed into the page plane

d) $\frac{12}{19}\frac{\upsilon}{d}$, directed out of the page plane

e) $\frac{24}{19}\frac{\upsilon}{d}$, directed into the page plane

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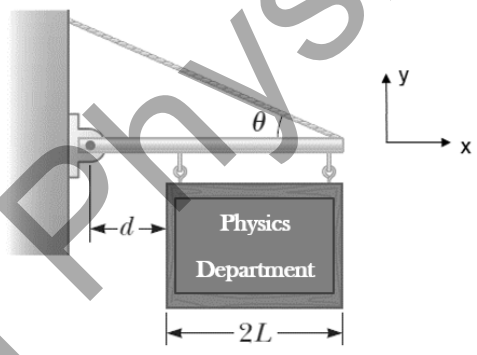
As shown in the figure, a uniform sign with weight G and width $2L$ hangs from a horizontal beam of negligible mass, hinged to the wall and supported by a cable. The system is in static equilibrium.
Based on this information, answer the following two questions (13-14).



13) What is the tension force in the cable in terms of G, d, L ve θ?

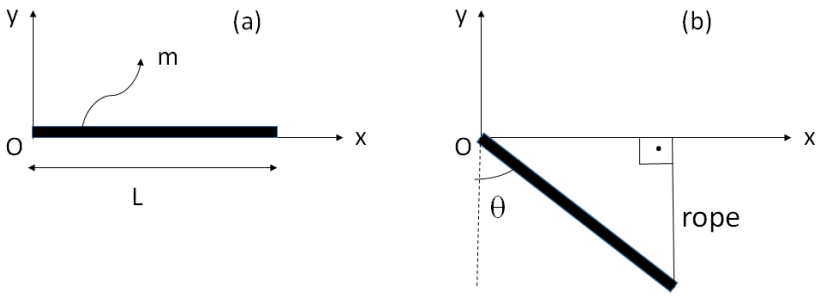
a) $\frac{G(d+2L)}{\sin\theta(d+L)}$ b) $\frac{G(d+L)}{\cos\theta(d+2L)}$ c) $\frac{G(d+2L)}{\cos\theta(d+L)}$

d) $\frac{G(d+L)}{\sin\theta(d+2L)}$ e) $\frac{2G(d+L)}{\sin\theta(d+2L)}$

14) What is the y-component of the reaction force exerted on the beam by the wall in terms of G, L, and d?

a) $\frac{2GL}{d+2L}$ b) $\frac{GL}{d+2L}$ c) $\frac{GL}{d+L}$ d) $\frac{2GL}{d+L}$ e) $\frac{GL}{2(d+2L)}$

A thin rod of length L and mass m in figure (a) is suspended in a way that it can rotate freely without friction about an axis perpendicular to the plane of the figure passing through point O, as in figure (b), and balanced with the help of a rope.
Based on this information, answer the following three questions (15-17).



15) Assuming that the rod is homogeneous, what is the tension force in the rope for the static equilibrium state in figure (b)? (g is the acceleration of gravity.)

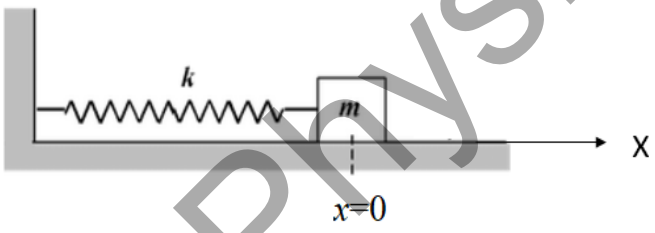
a) $\frac{mg\sin\theta}{2}$ b) $\frac{mg}{2\sin\theta}$ c) $\frac{mgL}{2}$ d) $\frac{mg\sin\theta}{2L}$ e) $\frac{mg}{2}$

16)

17) If the linear mass density of the rod in figure (a) changes by $\lambda = \frac{x^3}{L}$, what is the tension force in the rope for the static equilibrium state in figure (b)? (g is the acceleration of gravity.) (x appeared in linear mass density is the distance from point O.)

a) $\frac{4mg\sin\theta}{5L}$ b) $\frac{3mg}{5\sin\theta}$ c) $\frac{4mg}{5}$ d) $\frac{3mgL}{2}$ e) $\frac{3mg}{5}$

The variation of the position of an oscillating body with time around x=0 equilibrium point in the body-spring system on the frictionless horizontal plane is given by $x(t) = 3\cos\left(\frac{\pi}{2}t + \varphi\right)$ (m). The spring constant of the spring is k= 9 (N/m); at t=1 (s), the object is at x=-3 (m). Based on this information, answer the following three questions (18-20).



18) What is the phase constant of the simple harmonic motion in (rad) unit?

a) $\frac{\pi}{3}$ b) 2π c) $\frac{\pi}{4}$ d) π e) $\frac{\pi}{2}$

19) What is the velocity vector of the object at t=2 (s) in (m/s) unit?

a) $\frac{9}{2}\hat{i}$ b) $-\frac{9}{2}\hat{i}$ c) $\frac{3}{2}\hat{i}$ d) $-\frac{3}{2}\hat{i}$ e) 0

20) What is the kinetic energy of the object in (J) unit, when its distance from the equilibrium state is 1/3 of the amplitude of motion?

a) $\frac{27}{4}$ b) $\frac{27}{2}$ c) 27 d) 36 e) 18

No		No	
1.	C	**11.**	A
2.	E	**12.**	C
3.	D	**13.**	D
4.	A	**14.**	B
5.	A	**15.**	E
6	E	**16.**	
7	A	**17.**	C
8.	C	**18.**	E
9.	B	**19.**	A
10.	D	**20.**	D