General Physics: Class Exam III

12 November 2019

Name: Solution **Total:** /70

Instructions

- There are 8 questions on 6 pages.
- Show your reasoning and calculations and always explain your answers.

Physical constants and useful formulae

$g = 9.8\,\mathrm{m/s^2}$ $G = 6.67 \times 10^{-11}\,\mathrm{Nm^2/kg^2}$

Cylinder/disk: $I = \frac{1}{2}MR^2$ Hoop: $I = MR^2$ Solid sphere: $I = \frac{2}{5}MR^2$

Question 1

A 4.0 kg object on a horizontal sheet of ice is initially at rest. A rope pulls on it, does 128 J of work and then stops pulling. No other forces do work on the object.

a) Determine the kinetic energy of the object after the the rope has stopped pulling.

+1 [$W_{net} = \Delta K = K_f - K_i$ $\Rightarrow$ $K_f = 128\,\mathrm{J}$ +1

128J

b) Determine the speed of the object after the the rope has stopped pulling.

+1 $K = \frac{1}{2}mv^2$

+3 [$128\,\mathrm{J} = \frac{1}{2}\,4.0\,\mathrm{kg}\,v^2$

$128\,\mathrm{J} = 2.0\,\mathrm{kg}\,v^2$

$v^2 = 64\,\mathrm{m^2/s^2}$ $\Rightarrow$ $v = 8.0\,\mathrm{m/s}$

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Question 2

A 5.0 kg box can move along a frictionless track. The box is pushed against a spring, whose spring constant is 2000 N/m, compressing it by 0.20 m. It is held at rest in this position and is then released. It leaves the spring before it reaches the bottom of the ramp.

a) Determine the speed of the box after it leaves the spring.

either once (+1)

$E_f = E_i$

$K_f + U_{gf} + U_{spf} = K_i + U_{gi} + U_{spi}$

$v_i = 0\,m/s$ $\quad v_f =$
$y_i = 0m$ $\quad y_f = 0m$
$x_i = 0.20m$ $\quad x_f = 0m$

$\frac{1}{2}mv_f^2 + mgy_f + \frac{1}{2}kx_f^2 = \frac{1}{2}mv_i^2 + mgy_i + \frac{1}{2}kx_i^2$

$\frac{1}{2}mv_f^2$ (+1) $\quad mgy_f$ (0) $\quad \frac{1}{2}kx_f^2$ (0, +1) $\quad \frac{1}{2}mv_i^2$ (0) $\quad mgy_i$ (0) $\quad \frac{1}{2}kx_i^2$ (+1)

(+3)

$\frac{1}{2}\,5.0\,kg\,v_f^2 = \frac{1}{2}\,2000\,N/m\,(0.20m)^2$

$2.5\,kg\,v_f^2 = 40\,J \Rightarrow v_f^2 = 16\,m^2/s^2 \Rightarrow v_f = 4.0\,m/s$

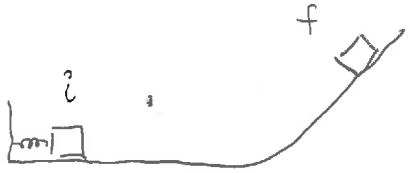
b) Determine the maximum height (above the horizontal) that the box reaches on the ramp.

* more space

either once (+3)

$E_f = E_i$

$K_f + U_{gf} + U_{spf} = K_i + U_{gi} + U_{spi}$



$v_i = 0\,m/s$ $\quad v_f = 0\,m/s$
$y_i = 0m$ $\quad y_f = ?$
$x_i = 0.20m$ $\quad x_f = 0m$

$\frac{1}{2}mv_f^2 + mgy_f + \frac{1}{2}kx_f^2 = \frac{1}{2}mv_i^2 + mgy_i + \frac{1}{2}kx_i^2$

$\frac{1}{2}mv_f^2$ (0) $\quad mgy_f$ (+1) $\quad \frac{1}{2}kx_f^2$ (0) $\quad \frac{1}{2}mv_i^2$ (0) $\quad mgy_i$ (0) $\quad \frac{1}{2}kx_i^2$ (+1)

(+3)

$5.0\,kg \times 9.8\,m/s^2\,y_f = \frac{1}{2}\,2000\,N/m\,(0.20m)^2$

$49\,kgm/s^2\,y_f = 40\,J$

$y_f = \frac{40\,J}{49\,kgm/s^2} = 0.82m$

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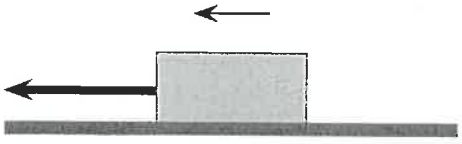
Question 3

A box, on a rough horizontal surface, is pulled by a rope to the left as illustrated. The box moves with constant speed. Which of the following (choose one) is true?



a) Which of the following (choose one) is true?

i) The rope does positive work, friction does positive work.
ii) The rope does positive work, friction does negative work.
iii) The rope does negative work, friction does positive work.
iv) The rope does negative work, friction does negative work.

+4

b) Would your answer change if the box were speeding up? Briefly explain your answer.

The forces are

$\vec{F}_{rope}$ $\vec{F}_{friction}$

motion

For the rope (+1)

$W_{rope} = F_{rope}\, d \cos 0^\circ$ (+1)

$= F_{rope} d \Rightarrow$ positive regardless

For friction $W_f = F_f d \cos 180^\circ$ (+1)

$\cos 180^\circ = -1$

$\Rightarrow$ $W_{friction}$ negative regardless

No change (+1)

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Question 4

Two people lift identical objects vertically using ropes. Alice does 400 J of work in 2.0 s when lifting her object. Bob does 300 J of work in 1.0 s when lifting his object. Which of the following is true?

i) The power delivered by Alice is the same as the power delivered by Bob.
ii) The power delivered by Alice is more than the power delivered by Bob.
iii) The power delivered by Alice is less than the power delivered by Bob.

+2

Briefly explain your answer.

$P = \frac{W}{\Delta t}$ (+1) or equiv

For Alice $P = \frac{400\,J}{2.0\,s} = 200\,W$

For Bob $P = \frac{300\,J}{1.0\,s} = 300\,W$

+4/3

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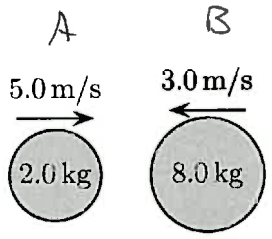
This means iii

Question 5

Two balls initially move directly toward each other as illustrated. The 2.0 kg ball moves with speed 5.0 m/s and the 8.0 kg ball with speed 3.0 m/s. The balls collide and subsequently the 8.0 kg ball moves left with speed 1.5 m/s. The balls are isolated from all other objects. Determine the velocity of the ~~8.0~~ 2.0 kg ball after the collision.



$v_{Ai} = 5.0\,m/s$

$v_{Bi} = -3.0\,m/s$

$v_{Af} = ?$

$v_{Bf} = -1.5\,m/s$

(+1) $p_{tot\,f} = p_{tot\,i}$

$p_{Af} + p_{Bf} = p_{Ai} + p_{Bi}$

(+1) $m_A v_{Af} + m_B v_{Bf} = m_A v_{Ai} + m_B v_{Bi}$

$2.0\,kg\ v_{Af} + 8.0\,kg\,(-1.5\,m/s) = 2.0\,kg \times 5.0\,m/s + 8.0\,kg \times (-3.0\,m/s)$ (+1 on $-1.5\,m/s$, +1 on $-3.0\,m/s$)

(+2) $2.0\,kg\ v_{Af} - 12\,kg\,m/s = 10\,kg\,m/s - 24\,kg\,m/s$

$\Rightarrow 2.0\,kg\ v_{Af} = -2.0\,kg\,m/s \Rightarrow$ **$v_{Af} = -1.0\,m/s$ left**

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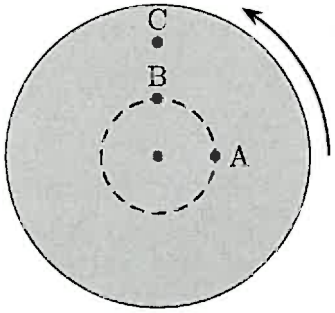
Question 6

A solid disk rotates at a constant rate about an axis through its center. Which of the following (choose one) is true regarding the angular velocities of the illustrated points?



i) $\omega_A = \omega_B = \omega_C$

ii) $\omega_A = \omega_B > \omega_C$

iii) $\omega_A = \omega_B < \omega_C$

iv) $\omega_C < \omega_B < \omega_A$

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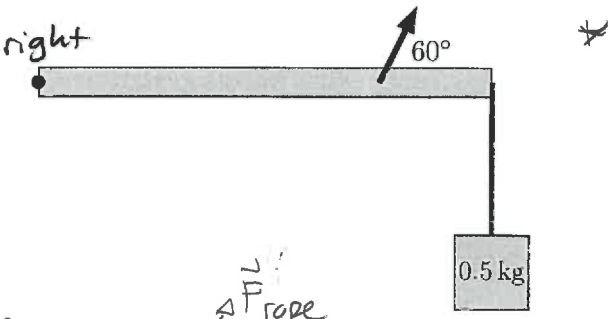
For a solid object ω is same everywhere

So [i]

* more space

Question 7

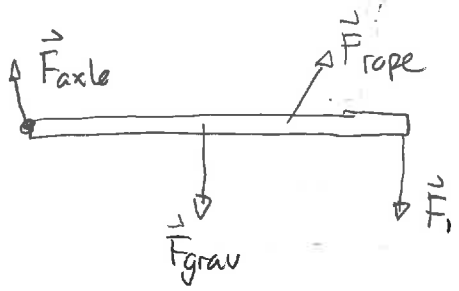
A 2.0 kg rod with length 1.0 m can pivot about its left end. A 0.50 kg masspiece is suspended from the ~~left~~ right end. A rope, connected 0.75 m from the left end pulls at an angle of 60° from the rod. The rod is horizontal and at rest. Determine the tension in the rope.



(+1) [$\tau_{net} = 0$

So

(+1) $\tau_{net} = \tau_{axle} + \tau_{grav} + \tau_{rope} + \tau_1$



In each case

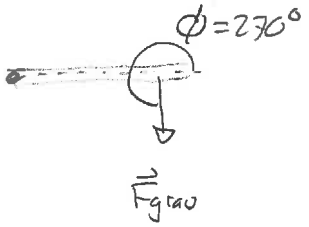
$\tau = rF\sin\phi$] (+1)

existence (+1) [1) axle (+1) $r = 0$ $\Rightarrow$ $\tau_{axle} = 0\ N\,m$

existence do this (+1) [2) gravity $r = 0.5m$

(+1) [$F = mg = 2.0\,kg \times 9.8\,m/s^2$

$= 19.6N$

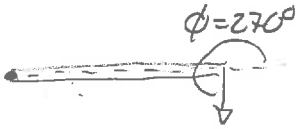


$\tau_{grav} = 0.5m \times 19.6N \sin 270° = -9.8\,Nm$ (+1) (+2)

3) rope

$\tau_{rope} = 0.75m\ F_{rope} \underbrace{\sin 60°}_{0.866}$ (+1) (+1)

(+1) $\tau_{rope} = 0.65m\ F_{rope}$



4) force 1 (+1) [$F = mg = 0.5kg \times 9.8m/s^2 = 4.9N$

$\tau_1 = 1.0m \times 4.9N \underbrace{\sin 270°}_{(+1)} = -4.9\,N\cdot m$] (+1)

(+1)

$\tau_{net} = 0$

solve (+1) (+1) (+1) [$\Rightarrow 0\,N\cdot m - 9.8\,N\cdot m + 0.65m\ F_{rope} - 4.9\,Nm = 0$

$\Rightarrow 0.65m\ F_{rope} = 14.7\,Nm$

$\Rightarrow F_{rope} = 23N$

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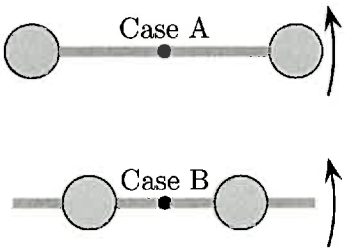
Question 8

Two barbells consist of identical balls attached to symmetrically to rods. The balls for case A are further from the center than for case B. Identical forces are exerted at the right end of each rod. Which of the following (choose one) is true regarding the angular acceleration of each?



i) Same angular acceleration for both.

ii) Larger angular acceleration for A.

iii) Smaller angular acceleration for A.

+2 [

Briefly explain your answer.

+1 [$\tau_{net} = I\alpha$

The net torque is provided by the force at the right end.

same torque +1 [These are the same for the two cases. So τ_{net} is same

In case A the moment of inertia of the balls mr^2] +1 or some evidence is larger than for B since r is larger

+1

$\tau_{net} = I\alpha$

same larger A smaller A

+1

$\alpha = \frac{\tau_{net} \text{ same}}{I \text{ larger A}}$

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