****
QUESTION NO: 1
****

A uniform rod of length L=0.98 m and mass M=3.0 kg is free to rotate on a frictionless pin through one end (Fig. (5)). The rod has an angular speed of 4.0 rad/s when it was in the horizontal position. What is the angular speed at its lowest position?

A. 4.0 rad/s
B. 8.8 rad/s
C. 3.4 rad/s
D. 5.5 rad/s
E. 6.8 rad/s

****
QUESTION NO: 2
****

At a certain instant the position vector of a particle is given by r = (2i) m. The linear momentum p = (3j + k) kg.m/s. The angular momentum of the particle is:

A. (5j + k) kg.m**2/s
B. (-2j + 6k) kg.m**2/s
C. 0 kg.m**2/s
D. (2j + 5k) kg.m**2/s
E. (3j) kg.m**2/s

****
QUESTION NO: 3
****

A particle of mass 2.0 kg moves in a horizontal circle of radius R = 0.5 m. At a point Q, the velocity of the particle is 4.0 m/s in the (+y) direction. Determine the angular momentum of the particle about the point P as shown in Fig (7).

A. 0 kg.m**2/s
B. (8.0 j) kg.m**2/s
C. (4.0 j) kg.m**2/s
D. (8.0 k) kg.m**2/s
E. (4.0 k) kg.m**2/s

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****
QUESTION NO: 4
****

Three identical particles each of mass = 1 kg are placed in the xy plane. The position vector of the first is r1 = (1i + 4j) m and the second is r2 = (3i + 1j) m. What would be the position vector of the third particle if the center of mass of the three particles were at (3 m,3 m)?

A. r3 = (4i + 3j) m
B. r3 = (5i + 4j) m
C. r3 = (2i - 6j) m
D. r3 = (1i + 2j) m
E. r3 = (3i - 1j) m

****
QUESTION NO: 5
****

An escalator, moving with constant speed, is used to take 20 people (60 kg each) per minute from ground floor of Al-Rashed Mall to the first floor, 5 m above (see Fig (1)). Neglecting friction, the average power required is:

A. 200 W
B. 100 W
C. 400 W
D. 980 W
E. 1960 W

****
QUESTION NO: 6
****

A simple pendulum consists of a 2.0 kg mass attached to a string of length = 1.0 m. It is released from rest at X as shown in Fig (2). Its speed at the lowest point Y is:

A. 3.1 m/s
B. 5.2 m/s
C. 0.0 m/s
D. 1.6 m/s
E. 4.4 m/s

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****
QUESTION NO: 7
****

Fig (11) shows a uniform horizontal beam (length = 10 m, mass = 25 kg) that is pivoted at the wall, with its far end supported by a cable that makes an angle of 50 deg with the horizontal. If a person (mass = 60 kg) stands 3.0 m from the pivot, what is the tension in the cable?

A. 300 N
B. 420 N
C. 830 N
D. 390 N
E. 200 N

****
QUESTION NO: 8
****

A disk (A) of mass = 2.00 kg and radius = 30.0 cm rotates with angular velocity = 20.0 rad/s. Another disk (B) of mass = 1.00 kg and radius = 10.0 cm rotates with angular velocity = 20.0 rad/s in the opposite direction is dropped onto disk (A) (see Fig (9)). Calculate the final angular velocity of the two disks together.

A. 12.5 rad/s
B. 20.0 rad/s
C. 17.9 rad/s
D. 15.2 rad/s
E. 6.70 rad/s

****
QUESTION NO: 9
****

A disk of radius 20 cm rotating at 42 rad/sec stops (assume constant deceleration) after 10 sec. Through how many radians does the disk turn during this time?

A. 210 rad
B. 440 rad
C. 150 rad
D. 320 rad
E. 900 rad

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****
QUESTION NO: 10
****

A box is moving with a speed of 9.10 m/s to the right. After it has moved a distance = d on a rough horizontal surface (mu = 0.6) its speed is reduced to 3.69 m/s. Find the value of d.

A. 3.22 m
B. 2.33 m
C. 8.44 m
D. 5.88 m
E. 4.00 m

****
QUESTION NO: 11
****

A disk is rotating about an axel through its center O when two forces F1 = 10 N and F2 = 15N are applied on it as shown in Fig (4). The moment of inertia of the disk about O is 0.036 kg.m**2. If the system starts from rest, find the angular speed at time = 3.0 s.

A. 100 rad/s
B. 25 rad/s
C. 15 rad/s
D. 80 rad/s
E. 130 rad/s

****
QUESTION NO: 12
****

A projectile of mass 0.50 kg is fired with an initial speed of 10 m/s at an angle of 60 deg above the horizontal. The total mechanical energy of the projectile at its highest point is:

A. 25.0 J
B. 0.0 J
C. 6.25 J
D. 50.0 J
E. 18.8 J

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****
QUESTION NO: 13
****

A 3.0 kg mass starts from rest and slides a distance d = 1.0 m down a frictionless 60 deg incline, where it contacts an unstressed spring as in Fig (3). The mass slides an additional 35 cm as it is brought momentarily to rest by compressing the spring. Find the spring constant of the spring.

A. 262 N/m
B. 363 N/m
C. 561 N/m
D. 465 N/m
E. 664 N/m

****
QUESTION NO: 14
****

For an isolated system, an inelastic collision is one in which:

A. momentum is conserved but kinetic energy is not conserved
B. neither momentum nor kinetic energy is conserved
C. momentum is not conserved but mass is conserved
D. the total impulse equals the change in kinetic energy
E. momentum is not conserved but kinetic energy is conserved

****
QUESTION NO: 15
****

A 2.00 kg object moving with a speed of 3.00 m/s collides with a 1.00 kg object initially at rest. Immediately after collision, the 2.00 kg object has a velocity of 1.73 m/s directed 30 deg from its initial direction of motion. What is the speed of the 1.00 kg just after collision?

A. 3.00 m/s
B. 1.50 m/s
C. 6.00 m/s
D. 3.46 m/s
E. 1.73 m/s

****

QUESTION NO: 16

****

A uniform ladder (length = 5.00 m, mass = 20.0 kg) is leaning against a frictionless wall at an angle of 53 deg above the horizontal. A 40.0 kg boy climbs 2.00 m up the ladder (see Fig (10). What is the magnitude of the friction force exerted on the ladder by the floor?

A. 521 N
B. 375 N
C. 124 N
D. 192 N
E. 250 N

****

QUESTION NO: 17

****

A 2.00 kg object is moving with a velocity of 20.0 m/s in (+x) direction. Under the influence of a force the object starts to move with velocity of 20.0 m/s along (+y) direction. Find the magnitude of the impulse of the force.

A. 56.6 N.s
B. 0 N.s
C. 28.3 N.s
D. 20.0 N.s
E. 40.0 N.s

****

QUESTION NO: 18

****

The four particles in Fig (6) are connected by rigid rods of negligible mass. Calculate the moment of inertia of this system about the x axis.

A. 93 kg.m**2
B. 72 kg.m**2
C. 23 kg.m**2
D. 34 kg.m**2
E. 63 kg.m**2

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****
QUESTION NO: 19
****

It takes 2.0 J of work to stretch a sprig 10 cm from its unstressed length. Calculate the length this spring will stretch from its unstressed (normal) length when a mass of 980 g is hung from it.

A. 3.6 cm
B. 3.2 cm
C. 2.0 cm
D. 2.8 cm
E. 2.4 cm

****
QUESTION NO: 20
****

A solid sphere of mass = 20 kg and radius = 1.5 m rolls from rest without slipping down a rough inclined plane (mu=0.3) that makes an angle = 30 deg with the horizontal (see Fig (8)). Calculate the total kinetic energy of the rolling sphere at the bottom of the inclined plane.

A. 4010 J
B. 0 J
C. 2200 J
D. 1230 J
E. 4900 J

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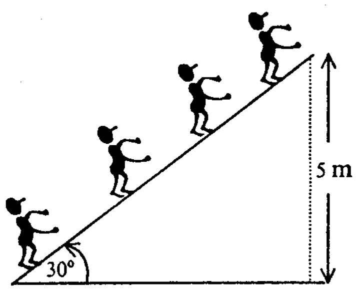

Figure 1

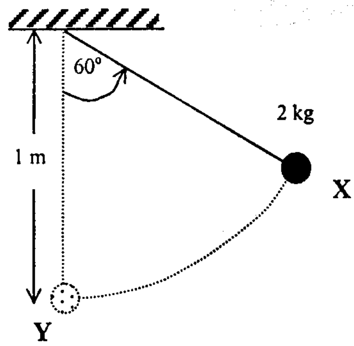

Figure 2

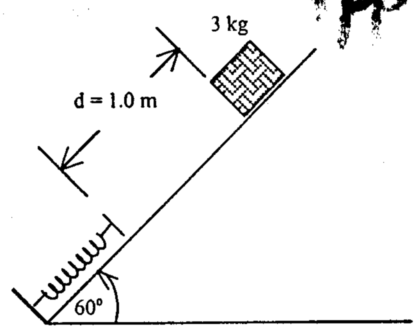

Figure 3

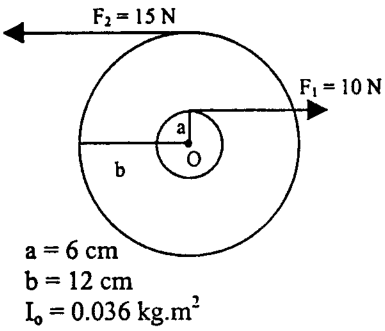

Figure 4

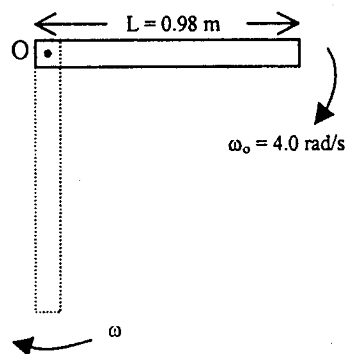

Figure 5

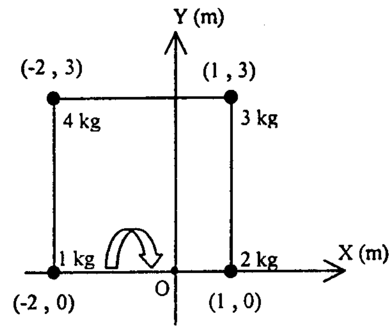

Figure 6

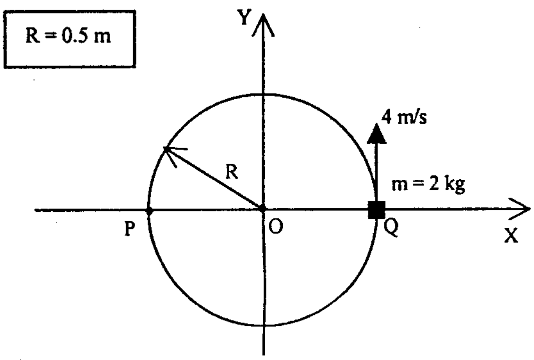

Figure 7

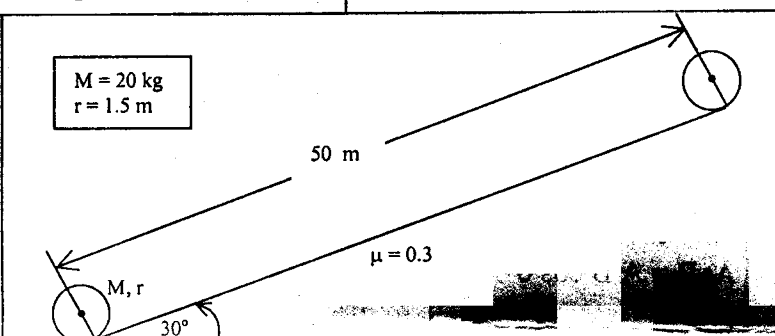

Figure 8

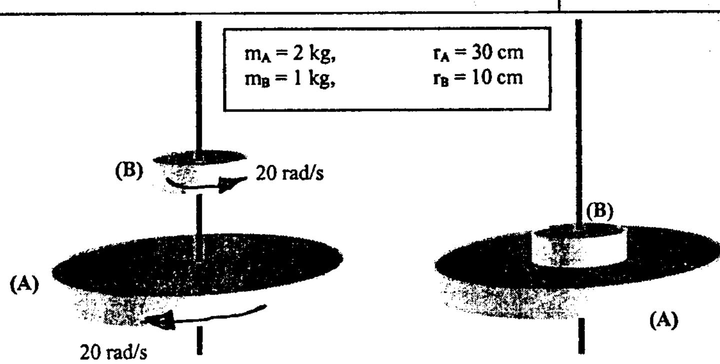

Figure 9

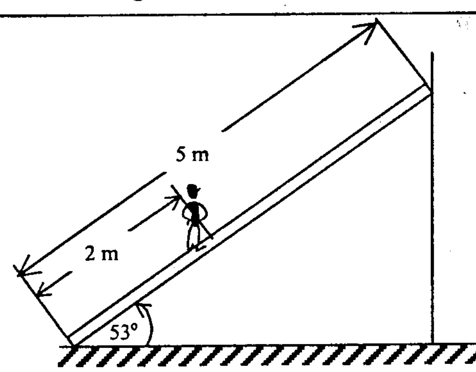

Figure 10

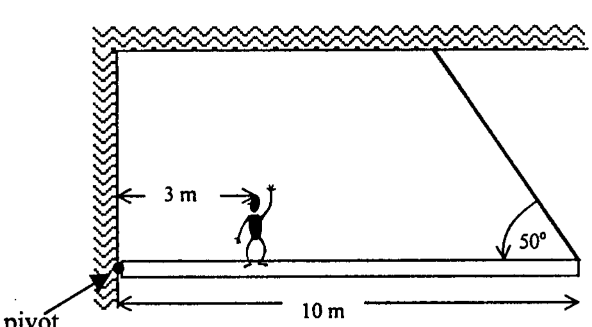

Figure 11

I_{cm} (solid sphere) $= \frac{2}{5}MR^2$

I_{cm} (cylinder) $= \frac{1}{2}MR^2$

I_{cm} (rod) $= \frac{1}{12}ML^2$

I_{end} (rod) $= \frac{1}{3}ML^2$

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PHYS-101 Formula Sheet for Major Exam II

$g = 9.80\ m/s^2$

$r = r_0 + v_0 t + \frac{1}{2} a t^2$

$v = v_o + at$

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

$x - x_o = \frac{(v_o + v)t}{2}$

$a_r = \frac{v^2}{r}$, $a_t = \frac{dv}{dt}$

$\vec{a} = \vec{a}_t + \vec{a}_r$

$\Sigma\vec{F} = m\vec{a} = \frac{d\vec{p}}{dt}$

$f_k = \mu_k N$

$f_s \leq \mu_s N$

$W = \vec{F} . \vec{s}$ if $\vec{F} = \text{Constant}$

$W = \int \vec{F} \bullet d\vec{s}$

$\mathbf{A} \bullet \mathbf{B} = A\,B \cos\theta$

$W_{net} = \Delta K = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$

$P = \frac{dW}{dt} = \vec{F} . \vec{v}$

$U_s = \frac{1}{2} k x^2$, $F_s = -kx$

$U_g = mgy$

$E = K + U$

$W_c = -\Delta U$

$W_{nc} = \Delta K + \Delta U = \Delta E$

(or $\Delta K + \Delta U = \Delta K_{int\text{-}nc} + \Delta K_{ext}$

$\vec{p} = m\vec{v}$

$\vec{I} = \Delta\vec{p} = \overline{F}\Delta t = \int \vec{F}\ dt$

$\vec{p}_{1i} + \vec{p}_{2i} = \vec{p}_{1f} + \vec{p}_{2f}$

$\vec{R}_{cm} = \frac{\Sigma m_i \vec{r}_i}{\Sigma m_i} = \frac{1}{M} \int \vec{r}\, dm$

$\vec{v}_{cm} = \frac{\Sigma m_i \vec{v}_i}{\Sigma m_i}$; $\vec{p}_{cm} = \Sigma m_i \vec{v}_i$

$\omega = \frac{d\theta}{dt}$; $\alpha = \frac{d\omega}{dt}$

$S = r\theta$, $v = r\omega$

$a_t = r\alpha$; $a_r = r\omega^2$

If $\alpha = \text{constant}$,

$\omega = \omega_o + \alpha t$

$\theta = \theta_o + \omega_o t + \frac{1}{2} \alpha t^2$

$\omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$

$I = \Sigma m_i r_i^2 = \int r^2\, dm$

$I_P = I_{cm} + M d^2$

$\vec{\tau} = \vec{r} \times \vec{F}$

$|\vec{A} \times \vec{B}| = AB \sin\theta$

$P = \frac{dW}{dt} = \tau\omega$

For a solid rotating about a fixed axis,

$K_{rot} = \frac{1}{2} I \omega^2$, $L_z = I\omega$

$W = \int \tau\, d\theta$

$\vec{L} = \vec{r} \times \vec{p} = m\vec{r} \times \vec{v}$

$\vec{\tau} = \frac{d\vec{L}}{dt}$

$\sum \tau_{ext} = \frac{dL}{dt} = I\alpha$

For static equilibrium,

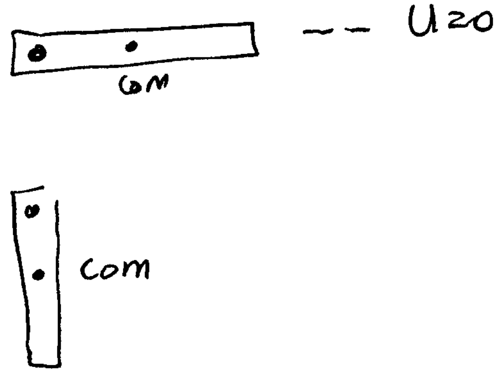
$\Sigma\vec{F} = 0$; $\Sigma\vec{\tau} = 0$

Q1

$$K_i + U_i = K_f + U_f$$

$$\frac{1}{2} I \omega_i^2 + 0 = \frac{1}{2} I \omega_f^2 + Mg\left(-\frac{L}{2}\right)$$

initial



final

$$I = I_{com} + M\left(\frac{L}{2}\right)^2$$

parallel-axis Theory.

$$\frac{1}{12} ML^2$$

$$I = \frac{1}{12} ML^2 + \frac{1}{4} ML^2 = \frac{1}{3} ML^2$$

$$\frac{1}{2}\left(\frac{1}{3} ML^2\right)\omega_i^2 = \frac{1}{2}\left(\frac{1}{3} ML^2\right)\omega_f^2 - Mg\frac{L}{2}$$

$$\frac{1}{3} L^2 \omega_f^2 = \frac{1}{3} L^2 \omega_i^2 + gL$$

$$\omega_f = \sqrt{\omega_i^2 + \frac{3g}{L}} = \sqrt{4^2 + \frac{3(9.8)}{0.98}}$$

$$= 6.8 \text{ rad/s}$$

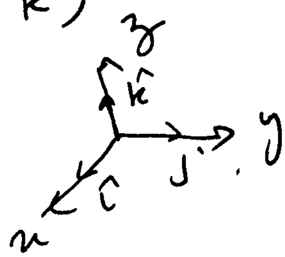
Q2

$$\vec{L} = \vec{r} \times \vec{p} = (2\hat{i}) \times (3\hat{j} + \hat{k})$$

$$= 2(3)(\hat{i} \times \hat{j}) + 2(\hat{i} \times \hat{k})$$

$$= 6\hat{k} + 2(-\hat{j})$$

$$= -2\hat{j} + 6\hat{k}$$



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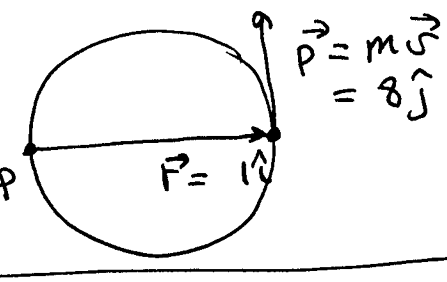
Q3

$\vec{l} = \vec{r} \times \vec{p} = (1\hat{i}) \times 8\hat{j}$

$= 8(\hat{i} \times \hat{j}) = 8\hat{k}\ \text{kg m}^2/\text{s}$



Q4

$$x_{com} = \frac{m_1 x_1 + m_2 x_2 + m_3 x_3}{m_1 + m_2 + m_3}$$

$$3 = \frac{1(1) + 1(3) + 1(x_3)}{1+1+1} \Rightarrow x_3 = 9 - 4 = 5\ \text{m}$$

$$Y_{com} = \frac{m_1 y_1 + m_2 y_2 + m_3 y_3}{m_1 + m_2 + m_3}$$

$$3 = \frac{1(4) + 1(1) + 1(y_3)}{1+1+1} \Rightarrow y_3 = 9 - 5 = 4\ \text{m}$$

$$r_3 = (5\hat{i} + 4\hat{j})\ \text{m}$$

Q5

$$P_{avg} = \frac{\Delta W}{\Delta t} = \frac{20((60)(9.8)(5))}{60} = 980\ \text{W}$$

work on one person is mgh

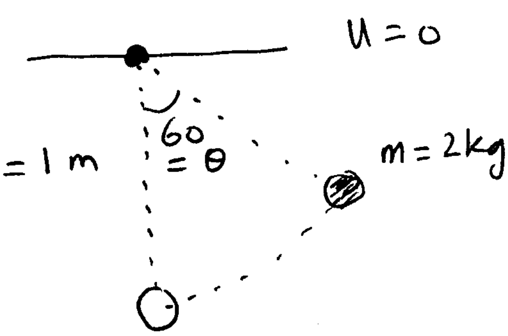
Q6

$K_i + U_i = K_f + U_f$

$0 + mg(-l\cos\theta) = \frac{1}{2} m v^2 + mg(-l)$

$v = \sqrt{2g(l - l\cos\theta)}$

$= \sqrt{2(9.8)(1 - \cos 60)} = 3.1\ \text{m/s}$



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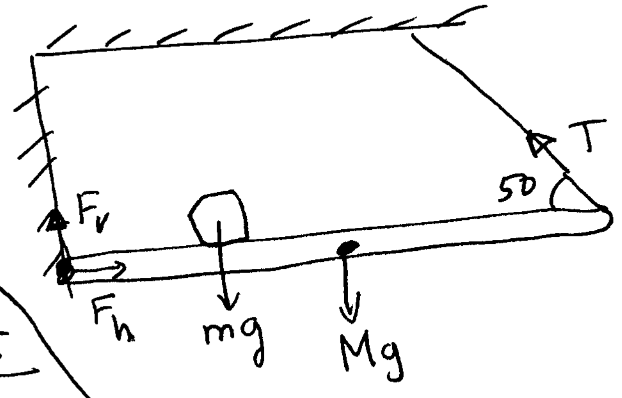
Q7. Torque about pivot point = 0

$$-mg(3) - Mg(5) + T\sin 50\,(10) = 0$$

$$T = \frac{mg(3) + Mg(5)}{10\sin 50}$$

$$= \frac{60(9.8)(3) + (25)(9.8)5}{10\sin 50}$$

$$= 393\ N \approx 390\ N$$



$$\vec{\tau} = \vec{r} \times \vec{F}$$

$$\tau = rF\sin\theta$$

Q8

$$\vec{L}_i = \vec{L}_f$$

$$I_A\vec{\omega}_A + I_B\vec{\omega}_B = (I_A + I_B)\vec{\omega}$$

$$\tfrac{1}{2}(2)(0.3)^2(-20) + \tfrac{1}{2}(1)(0.1)^2(20) = \left(\tfrac{1}{2}(2)(0.3)^2 + \tfrac{1}{2}(1)(0.1)^2\right)\omega$$

$$\omega = \frac{\tfrac{1}{2}(2)(0.3)^2(-20) + \tfrac{1}{2}(1)(0.1)^2(20)}{\tfrac{1}{2}(2)(0.3)^2 + \tfrac{1}{2}(1)(0.1)^2} = -17.9\ \text{rad/s}$$

magnitude of $\omega = 17.9$ rad/s

Q9

$$\theta - \theta_0 = \frac{\omega + \omega_0}{2}t$$

$$= \frac{0 + 42}{2}(10) = 210\ \text{rad}$$

Q10

$$W = \Delta K + \Delta U + \Delta E_{th}$$

$$0 = \Delta K + 0 + (\mu_k N)d$$

$$0 = \tfrac{1}{2}mv_f^2 - \tfrac{1}{2}mv_i^2 + \mu_k(mg)d$$

$$d = \frac{\tfrac{1}{2}(9.1)^2 - \tfrac{1}{2}(3.69)^2}{(0.6)(9.8)} = 5.88\ m$$

$\Delta U = 0$ because it moves on a horizontal surface

$W = 0$ because no work done by an external force

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P-4

Q11

$\omega = \omega_0 + \alpha t$

ω_0 = 0 (from rest); α: find it from Newton's second law

$\tau = I\alpha$

$-aF_1 + bF_2 = I\alpha$

$\alpha = \frac{-(0.06)(10) + (0.12)(15)}{0.036}$

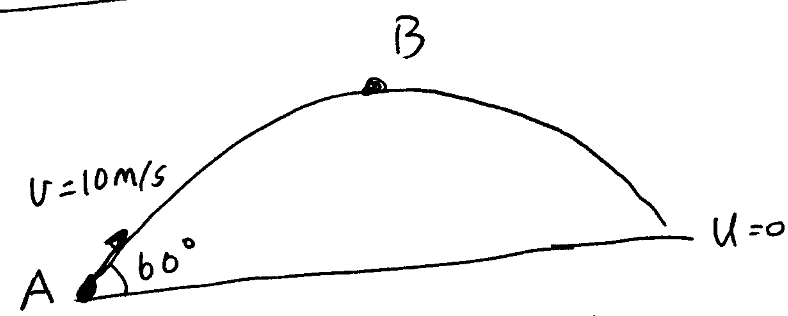
$= 33.3 \text{ rad/s}^2$

$\omega = (33.3)(3)$

$= 100 \text{ rad/s}$

Q12

our system consists of the projectile and the earth. Since there is no external force doing work on our system, the mechanical energy is conserved.



$E_{mech,A} = E_{mech,B} = K + U$

$= \frac{1}{2} m v_A^2 = \frac{1}{2}(0.5)(10)^2 = 25 \text{ J}.$

Q13

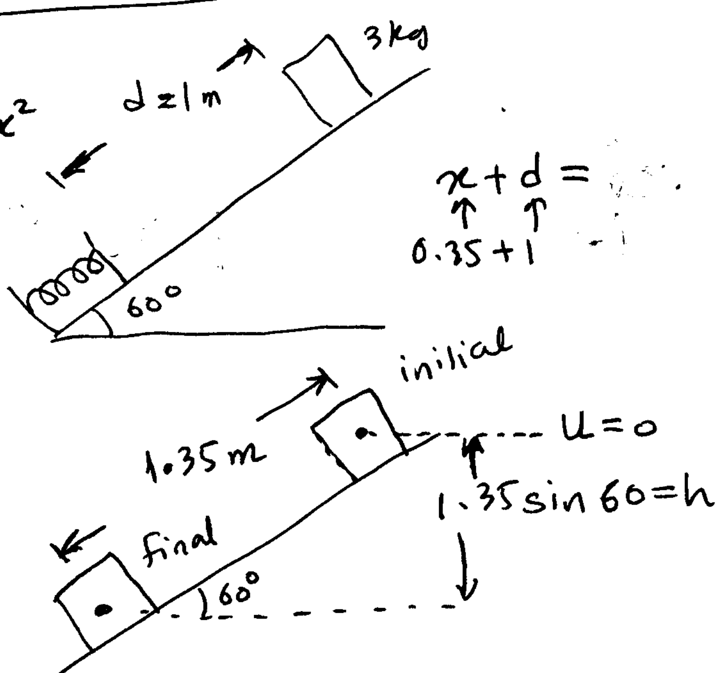
$K_i + U_i = K_f + U_f$

$0 + 0 = 0 + mg(-h) + \frac{k}{2}x^2$

$k = \frac{2mgh}{x^2}$

$= \frac{2(3)(9.8)(1.3 \sin 60)}{(0.35)^2}$

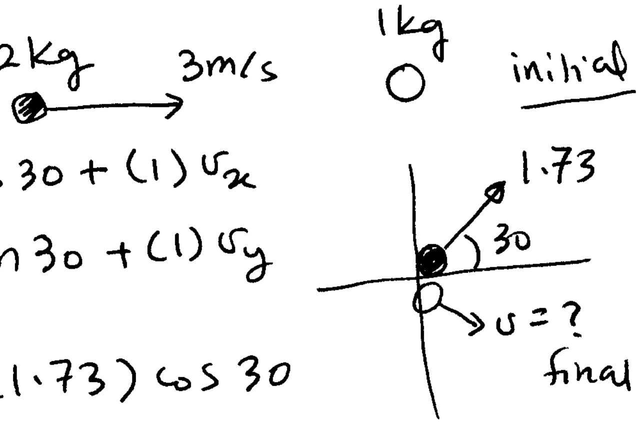
$= 561 \text{ N/m}$



Q14 momentum is conserved but kinetic energy is not conserved

Q15 conservation of linear momentum

$\vec{P_i} = \vec{P_f}$



Along x: $2(3) = 2(1.73)\cos 30 + (1)\,v_x$

$0 = 2(1.73)\sin 30 + (1)\,v_y$

$v_x = 2(3) - 2(1.73)\cos 30$

$v_y = -2(1.73)\sin 3\theta$

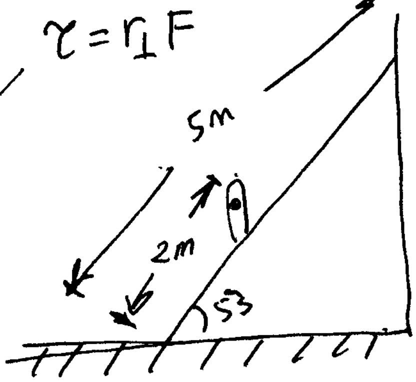
$v = \sqrt{v_x^2 + v_y^2} = 3.47 \text{ m/s}$

Q16

$\tau = r_\perp F$

$F_{net,x} = 0 = -N_1 + f_s$

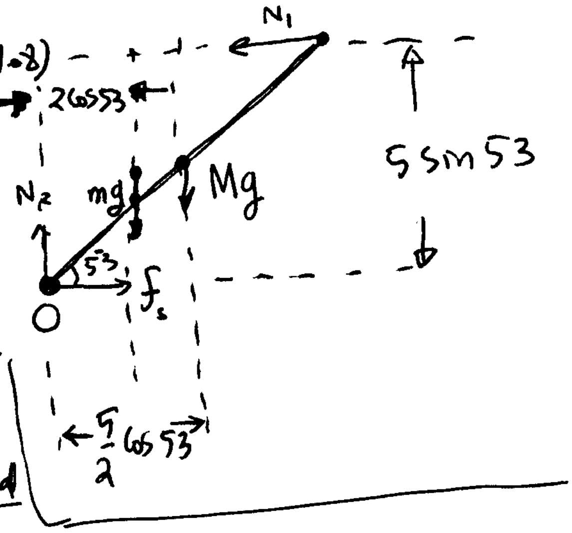
$\Rightarrow \boxed{f_s = N_1}$



$0 = \tau_0 = -(2\cos 53)(mg)$
$\quad - (\frac{5}{2}\cos 53)(Mg)$
$\quad + (5\sin 53)\,N_1$

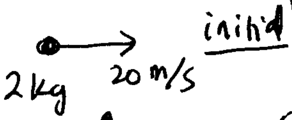
$N_1 = \dfrac{2\cos 53(40)(9.8) + \frac{5}{2}\cos 53(20)(9.8)}{5\sin 53}$

$= 192\text{ N} = f_s$

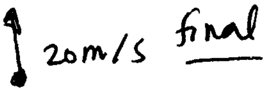


Q17 $\vec{J} = \vec{P_f} - \vec{P_i}$

$= m\vec{v_f} - m\vec{v_i}$



$= 2(20\hat{j}) - 2(20\hat{i})$

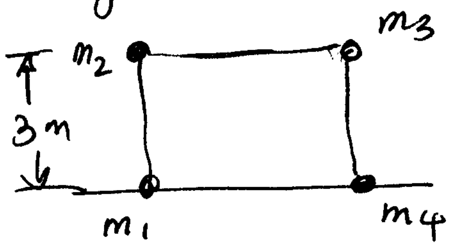


$J = \sqrt{J_x^2 + J_y^2}$

$= \sqrt{(40)^2 + (40)^2} = 56.6 \text{ N.s}$

Q18

$$I = \sum_{i=1}^{4} m_i r_i^2 = m_1(0)^2 + m_2(3)^2 + m_3(3)^2 + m_4(0)^2$$
$$= 4(3)^2 + 3(3)^2 = 63 \text{ kg m}^2$$



Q19

$$\left.\begin{array}{l} U = \frac{k}{2}x^2 \\ 20 = \frac{k}{2}(0.1)^2 \end{array}\right\} \Rightarrow k = 400 \text{ N/m}$$

$$F = -kd$$
$$-mg = -kd \Rightarrow d = \frac{(0.98)(9.8)}{400} = 0.024 m = 2.4 cm$$

Q20

$$W = \Delta K + \Delta U + \Delta E_{th}$$

$W = 0$: no work done by an external force to our sphere-eath system

$\Delta E_{th} = 0$: no slipping

$$K_i + U_i = K_f + U_f$$

$$0 + 0 = K_f + mg(-h)$$

$$K_f = mgh = 20(9.8)(50)\sin 30$$
$$= 4900 J$$