Midterm 2 - Winter 2015

Physics 1A, Dr. Mostafa El Alaoui

Tuesday, February 24

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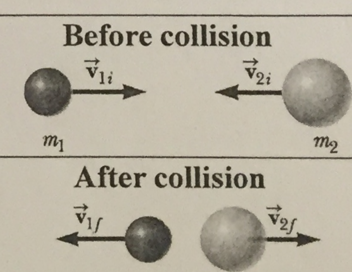
Please do the following 4 problems. Show all work and reasoning. Use the back of the page if necessary and circle your final answer. **Write your name and student ID on your exam.**

Problem	Points
1	25
2	25
3	25
4	21
TOTAL	96

$$v_{1f} = \left(\frac{m_1 - m_2}{m_1 + m_2}\right) v_{1i} + \left(\frac{2m_2}{m_1 + m_2}\right) v_{2i}$$

$$v_{2f} = \left(\frac{2m_1}{m_1 + m_2}\right) v_{1i} + \left(\frac{m_2 - m_1}{m_1 + m_2}\right) v_{2i}$$



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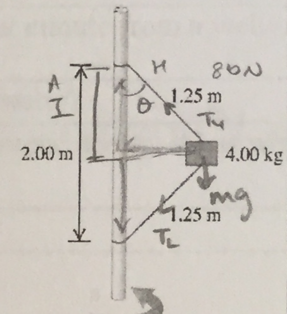
	Problem 1
	The 4.00-kg block in the figure is attached to a vertical rod by means of two strings. When the system rotates about the axis of the rod, the strings are extended as shown in the diagram and the tension in the upper string is 80.0 N. 
(10 Points)	a) What is the tension in the lower cord?
(8 Points)	b) How many revolutions per minute does the system make?
(7 Points)	c) Find the number of revolutions per minute at which the lower cord just goes slack.

SOH
CAH

1. a) $\cos\theta = \frac{1}{1.25}$ $\quad \therefore \arccos\left(\frac{1}{1.25}\right) = \theta$

$(\uparrow)$: $T_u \cos\theta = mg + T_L \cos\theta$

$T_u \cos\theta - mg = T_L \cos\theta$

$\therefore T_L = \dfrac{T_u \cos\theta - mg}{\cos\theta} = \underline{\underline{31N}}$

b.) $T_u \sin\theta + T_L \sin\theta = \dfrac{mv^2}{R}$

$\sqrt{\dfrac{R}{m}\left(T_u \sin\theta + T_L \sin\theta\right)} = v$

where $R = \sqrt{1.25^2 - 1^2} = \frac{3}{4}$ m

$\therefore v = 3.53\ ms^{-1}$

where $v = \omega r \quad \therefore \omega = \frac{v}{r}$

$\therefore \omega = 4.71\ rads^{-1}$

$\omega = 4.71 \times \frac{60}{2\pi}$

$= \underline{45.0\ rpm}$

c) $T_L = 0$

$\therefore (\uparrow)$ $T_u \cos\theta = mg$ ①

$(\rightarrow)$ $T_u \sin\theta = \dfrac{mv^2}{r}$ ②

$\therefore \dfrac{②}{①} \Rightarrow \tan\theta = \dfrac{v^2}{gr}$

$\sqrt{gr\tan\theta} = v = \omega r$

$\frac{1}{r}\sqrt{gr\tan\theta} = \omega$

$\omega = 3.13$

$\therefore \omega = 3.13 \times \frac{60}{2\pi}$

$= 29.9$ rpm $\approx \underline{\underline{30 rpm}}$

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	Problem 2
	A pump is required to lift a mass of 800 kg of water per minute from a well of depth 14.0 m and eject it with a speed of 18.0 m/s.
(9 points)	a) How much work is done per minute in lifting the water?
(8 points)	b) How much work is done in giving the water the kinetic energy it has when ejected?
(8 points)	c) What must be the power output of the pump?

2.a.) work done to lift water (W_1) $= mgh$

$= 800 \times 9.8 \times 14 = 109760 \text{ J}$

$\approx 1.1 \times 10^5 \text{ J}$

b.) work done to give KE (W_2) $= \frac{1}{2} m v^2$

$= \frac{1}{2}(800)(18)^2 = 129600 \text{ J}$

$\approx 1.3 \times 10^5 \text{ J}$

c.) Total average power per min $= \frac{W_1 + W_2}{60} = 3989.33 \text{ W}$

$\approx 4000 \text{ W}$

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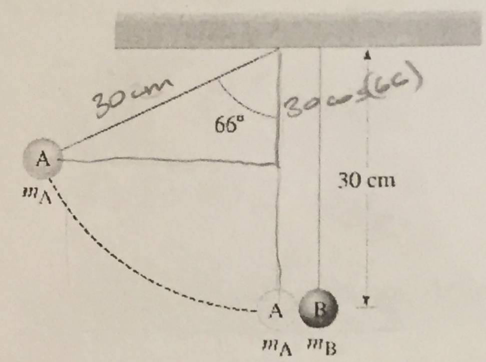
	Problem 3
	Two balls, of masses $m_A = 45g$ and $m_B = 63g$, are suspended as shown in the figure. The lighter ball is pulled away to a θ=66° angle with the vertical and released. The two balls then <u>collide elastically</u>. Assume that the positive *x* axis is directed to the right. (Figure 1) 
(10 points)	a) What is the velocity of the lighter ball before impact?
(8 points)	b) What is the velocity of each ball after the elastic collision?
(7 points)	c) What will be the maximum height of each ball after the elastic collision?

3.a) $K_1 + U_{g1} = K_2 + U_{g2}$

$mgh = \frac{1}{2} m u_A^2$

$\sqrt{2gh} = u_A$, where $h = 30cm - 30\cos(66)cm$

$\therefore\ u_A = \underline{1.87\ ms^{-1}}$

b.) $m_A u_A = m_B v_B + m_A v_A$ ①

$\frac{1}{2} m_A u_A^2 = \frac{1}{2} m_B v_B^2 + \frac{1}{2} m_A v_A^2$ ②

$\frac{②}{①}$ = $u_A = v_B + v_A$,

$\therefore$ we get : $v_A = \left[\frac{m_A - m_B}{m_A + m_B}\right] u_A = \underline{-0.311\ ms^{-1}}$

$v_B = \left[\frac{2m_A}{m_A + m_B}\right] u_A = \underline{1.56 ms^{-1}}$

c.) Ball B :

$K_1 + U_{g1} = K_2 + U_{g2}$

$\frac{1}{2} m v_B^2 = m g h_B$

$\frac{v_B^2}{2g} = h_B$

$h_B = 0.124 m$

$\approx \underline{12.4\ cm}$

Ball A :

$K_1 + U_{g1} = K_2 + U_{g2}$

$\frac{1}{2} m v_A^2 = m g h_A$

$\frac{v_A^2}{2g} = h_A$

$h_A = 4.93 \times 10^{-3} m$

$\approx \underline{0.49 cm}$

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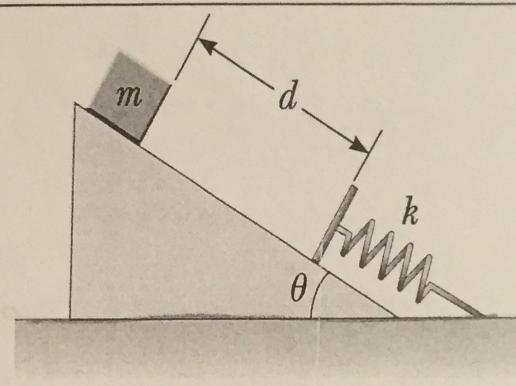
	Problem 4
	An object of m=2.0 kg starts from rest and slides a distance d down a frictionless incline of angle θ=30°. It then hits an unstressed spring (of force constant k=400 N/m) of negligible mass as shown in figure. When the block momentarily stops, it has compressed the spring by x=0.5 m. 
(10 points)	a) What is the distance d?
(10 points)	b) What is the distance between the point of the first block-spring contact and the point where the block's speed is greatest?
(5 points)	c) Calculate the maximum speed of the block along the incline?

4.a) $\overset{0}{K_1} + U_{g1} + \overset{0}{U_{s1}} = \overset{0}{K_2} + \overset{0}{U_{g2}} + U_{s2}$

$mgd\sin\theta = \frac{1}{2}kx^2$

$d = \frac{kx^2}{2mg\sin\theta} = \underline{\underline{5.10m}}$ 8/10

b.) Max speed is when the change in KE is max. At this point lets call the distance of spring compressed as x.

$\therefore \Delta KE = \frac{1}{2}kx^2 - mg(d-x)\sin\theta$

$\therefore \frac{dKE}{dx} = 0 \quad \therefore kx + mg\sin\theta = 0$

$\therefore x = -\frac{mg\sin\theta}{k}$

10/10

$x = -0.0245\,m$

$|x| = \underline{0.0245\,m}$

c.) The max speed would be at this point x (Remember x is in the negative direction)

$\therefore \frac{1}{2}mv^2 = \frac{1}{2}kx^2 + mg(d-x)\sin\theta$

$v = \sqrt{\frac{k}{m}x^2 + 2g(d-x)\sin\theta} = 7.095\,ms^{-1}$

$\approx \underline{\underline{7.1\,ms^{-1}}}$ 3/5