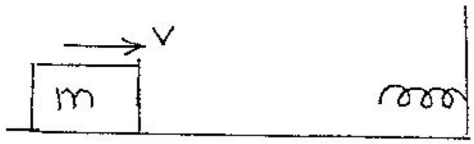
Physics 117a Exam #2 Answer Key

MC(50) ____ Prob11 ____ Prob12 ____ Prob13 ____ Total ____

Multiple choice, circle the correct answer (5 points each).

1.). A mass $m =$ ~~0.500~~ {0.5, 1.5, 2.5} kg is moving to the right on a frictionless table with a velocity $v = 3.00$ m/s. It collides with a horizontal, unstretched spring attached to a wall with spring constant $k = 0.250$ N/m as drawn. How far, measured from the unstretched length, does the spring compress when the mass has moved its farthest to the right?



A. 4.24 m
B. 7.35 m
C. 9.49 m
D. 11.2 m
E. 12.7 m

$E_i = E_f$

$\frac{1}{2} m v^2 = \frac{1}{2} k x^2 \quad \{v_f = 0\}$

$x = \sqrt{\frac{m}{k}}\, v = \sqrt{\frac{\{0.5, 1.5, 2.5\}\ \text{kg}}{.25\ \text{N/m}}} \times 3\ \frac{m}{s} = \{4.24,\ 7.35,\ 9.49\}$ m

2.) A book of mass ~~1.50~~ {1.50, 2.50, 3.50} kg is sitting on a table of height 1.60 m above the floor. You slowly lower the book to the floor such that it arrives at the floor with zero velocity. How much work did you do on the book? Use

A. 23.5 J
B. 39.2 J
C. 0
D. -23.5 J
E. -39.2 J

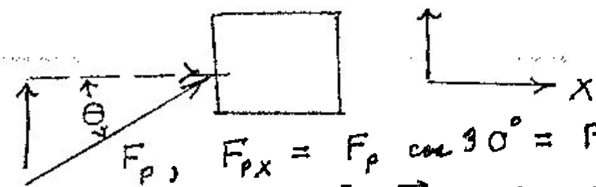
$W_{you} = \Delta U_G = mg(h_f - h_i)$

$= -mgh_i = -\{1.5, 2.5, 2.5\} \times 9.8 \times 1.60$

$= -\{23.5, 39.2, 39.2\}$ J

note: you pulling up, book moving down ⇒ W must be negative

3.) A block, attached to guide rails such that it can only move in the x-direction, starts from rest. You push on it with a force of ~~4.00~~ {4.00, 6.00, 8.00} N in a direction of 30.0deg. After 12.0 s, the block is moving with a velocity $v = 2.00$ m/s and has moved a distance $\Delta x = 12.0$ m. How much work have you done?



A. 41.6 J
B. 48.0 J
C. 62.4 J
D. 72.0 J
E. 83.1 J
F. 96.0 J

F_p, $F_{px} = F_p \cos 30^\circ = F_p \cdot .866$

$W = \vec{F} \cdot \Delta\vec{r} = F_{px}\, \Delta x$

$= .866\{4., 6., 8\} \cdot 12 = \{41.6,\ 62.4,\ 83.1\}$ J

Can also use kinetic equations to get a, then get m, use $W = \Delta K$

4.) A block of mass $m = 4.00$ kg is raised at a constant velocity to a height $h = 6.00$ m in a time $t = 4.00$ s by a crane. How much power is the crane producing.

{3.00, 2.00}

$P = \frac{\Delta W}{\Delta t} = \frac{mgh}{\Delta t} = \frac{4\,kg \times 9.8\,m/s \times 6\,m}{\{4., 3., 2.\}\,s} = \{58.8\ W, 78.4, 118.\}$

A. 49.7 W
B. 58.8 W
C. 78.4 W
D. 118. W
E. 136. W

5.) A weird spring is found to have a potential energy as a function of x (measured from its unstretched point) of $U(x) = a\,x^2 + b\,x^4$. The force exerted by the spring is given by:

$F(x) = -\frac{dU}{dx} = 2ax - 4bx^3$

A. $F(x) = +2ax + 4bx^3$
B. $F(x) = -2ax - 4bx^3$
C. $F(x) = +\frac{1}{3}ax^3 + \frac{1}{5}bx^5$
D. $F(x) = -\frac{1}{3}ax^3 - \frac{1}{5}bx^5$
E. $F(x) = a + bx^2$

6.) A superball of mass m is thrown against the wall and rebounds from the wall with a velocity equal in magnitude but opposite in direction to its original velocity. The interaction with the wall takes a time Δt. A piec of putty of the same mass and same initial velocity hits the wall and sticks. The interaction with the wall takes the same time Δt as the superball took. The average force of the wall on the superball is

$F_{ave} = \frac{\Delta p}{\Delta t}$

superball $\Delta p = mv - (-mv) = 2mv$

putty $\Delta p = mv - 0 = mv$

→ twice

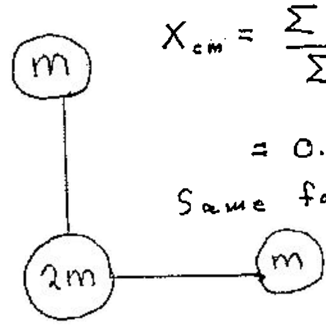
A. 1/4 of the force on the putty.
B. 1/2 of the force on the putty.
C. negligible compared to the force on the putty.
D. twice the force on the putty.
E. four times the force on the putty.

7.) A mass of $2m$ is located at the origin, a mass of m is located at (x, y)=(2 meters, 0) and a third mass of m is at (0, 2 meters) as drawn. The center-of-mass is located at:

$X_{cm} = \frac{\sum m_i x_i}{\sum m_i} = \frac{2\,m \times m}{4m}$

$= 0.500$ meters

Same for y



A. (0.250 meters, 0.250 meters)
B. (0.250 meters, 0.333 meters)
C. (0.333 meters, 0.333 meters)
D. (0.333 meters, 0.500 meters)
E. (0.500 meters, 0.500 meters)

8.) A block of mass m with a massless spring attached is moving to the right with speed v, and a second block of identical mass is moving to left with the same speed v. They collide. After the collision the first block is going to the left with speed $v/2$. What is the velocity of the second block after the collision? Take to the right as positive.

Conserve momentum

$P_i = P_f$

$mv - mv = -\frac{mv}{2} + mv_f = 0$

$v_f = +\frac{v}{2}$

A. v
B. v/2
C. 0
D. -v/2
E. -v

9.) A flywheel is rotating at 60.0 rev/s. The motor is turned off and it comes to a stop after rotating through {3.00 revolutions. What is its angular acceleration?

{3.00, 4.00}

use

$\omega^2 = \omega_0^2 + 2\alpha\Delta\theta$ ($\omega = 0$)

$\alpha = -\frac{\omega_0^2}{2\Delta\theta} = -\frac{(60\ rev/s)^2}{2\{\frac{3}{4}\ rev}$

$= \{600\ rev/s^2,\ 600,\ 450$

A. 600. rev/s^2
B. 450. rev/s^2
C. 225. rev/s^2
D. -225 rev/s^2
E. -450 rev/s^2
F. -600 rev/s^2

10.) A boy and a girl are standing on a merry-go-round. The mass of the boy is twice that of the girl. The boy is located at a distance from the center of the merry-go-round which is one-half the distance for the girl. The moment of inertia of the boy about the center of the merry-go-round is

A. 1/4 that of the girl.
B. 1/2 that of the girl.
C. the same as that of the girl.
D. 2 times that of the girl.
E. 4 times that of the girl.

$m_b = 2m_g$

$r_b = \frac{1}{2} r_g$

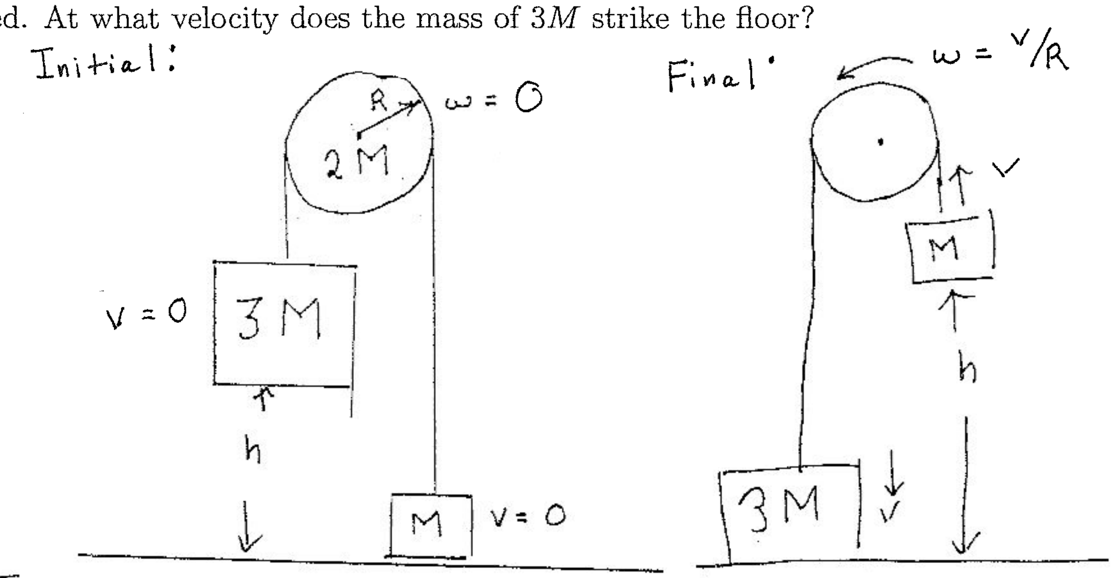
$I_b = m_b r_b^2 = (2m_g)(\frac{1}{2} r_g)^2$

$= \frac{1}{2} m_g r_g^2 = \frac{1}{2} I_g$

Problem, show your work clearly and logically, partial credit will be given. Please draw a box around your answer.

11.) [16 pointa] A mass M and a mass $3M$ are suspended from a frictionless pulley. The pulley has mass $2M$ and is a cylinder of radius $R = 0.500$ m. Initially, the mass $3M$ block is ~~3.00~~ m above the floor while the mass M is sitting on the floor. The blocks are released. At what velocity does the mass of $3M$ strike the floor?

{4.00, 3.00, 2.00}



Conserve Energy:

$E_i = U_g = (3M)gh$

$E_f = \frac{1}{2}(3M)v^2 + \frac{1}{2}Mv^2 + \frac{1}{2}I\omega^2 + U$

$I = \frac{1}{2}(2M)R^2, \quad \omega = \frac{v}{R}$

$E_f = \left(\frac{3}{2} + \frac{1}{2} + \frac{1}{2}\right)Mv^2 + Mgh$

$E_f = \frac{5}{2}Mv^2 + Mgh$

$3Mgh = \frac{5}{2}Mv^2 + Mgh$

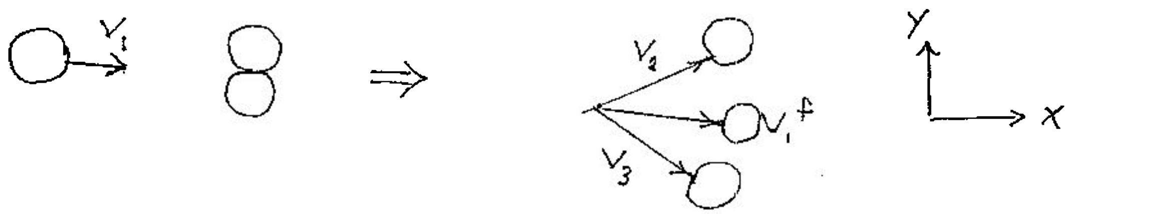
$2gh = \frac{5}{2}v^2$

$v = \sqrt{\frac{4}{5}gh} = \sqrt{\frac{4}{5} \cdot 9.8 \cdot \{4., 3, 2.\}} = \{5.60, 4.85, 3.96\}$ m/s

↑ 3M is going down

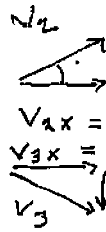
Problem, show your work clearly and logically, partial credit will be given. Please draw a box around your answer.

12.) [17 points] Three identical pool balls of mass 0.25 kg are sitting on a frictionless surface. The first ball is shot with a velocity $v_1 = 20.0$ m/s at the other two who are stationary and are touching and aligned perpendicular to the velocity of the first ball, as drawn below. Balls 2 and 3 recoil symmetrically with a speed of $v_2 = v_3 = \begin{cases} 6.00 \\ 8.00 \\ 10.0 \end{cases}$ m/s at angles ± 30 deg as measured from the direction of ball 1.



A.) What is the velocity of ball 1 after the collision?
B.) What fraction of the initial energy was converted into heat, sound, etc.?

A.) Conserve momentum



$V_{2Y} = V_2 \sin\theta$

$V_{2X} = V_2 \cos\theta$

$V_{3X} = V_3 \cos\theta$

$V_{3Y} = -V_3 \sin\theta$

y - direction

$P_{iY} = P_{fY}$

$0 = + m V_2 \sin\theta - m V_3 \sin\theta + m V_1^f$

$0 = m V_1^f$, or by observation, intuition, symmetry, etc

x - direction

$m V_1 = m V_2 \cos\theta + m V_3 \cos\theta + m V_1^f$

$V_1^f = V_1 - 2 V_2 \cos\theta = 20\,\text{m/s} - 2 \begin{cases} 6. \\ 8. \\ 10. \end{cases} \times .866$

$V_1^f = \begin{cases} 9.61 \\ 6.14 \\ 2.68 \end{cases}$ m/s

B.) $K_i = \frac{1}{2} m V_1^2 = \frac{1}{2}(.25)\, 20^2 \doteq 50\text{ J}$

$K_f = \frac{1}{2} m V_2^2 + \frac{1}{2} m V_3^2 + \frac{1}{2} m (V_1^f)^2$ (equal)

$= (0.25) \begin{cases} 6.^2 \\ 8.^2 \\ 10.^2 \end{cases} + \frac{1}{2}(.25) \begin{cases} 9.61^2 \\ 6.14^2 \\ 2.68^2 \end{cases} =$

$= \begin{cases} 9. \\ 16. \\ 25. \end{cases} + \begin{matrix} 11.5 \\ 4.7 \\ 0.9 \end{matrix} = \begin{cases} 20.5 \\ 20.7 \\ 25.9 \end{cases}$

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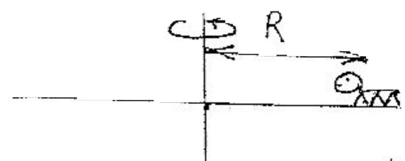
$$E_{heat} = K_i - K_f = 50\,J - \begin{cases} 20.5 \\ 20.7 \\ 25.9 \end{cases} J$$

$$= \begin{cases} 29.5 \\ 29.3 \\ 24.1 \end{cases}$$

$$\text{Fraction} = \frac{\begin{cases} 29.5 \\ 29.3 \\ 24.1 \end{cases}}{50} = \begin{cases} 0.590 \\ 0.586 \\ 0.482 \end{cases}$$

Problem, show your work clearly and logically, partial credit will be given. Please draw a box around your answer.

13.) [17 points] A bug is sitting on a record player a distance $R =$ ~~0.200~~ {0.250, 0.200, 0.150} m from the center. The coefficient of static friction between the bug and the record is $\mu_k = 0.200$ The record starts from rest and has an angular acceleration of $\alpha = 1.50$ rad/sec. At what time does the bug slide off the record?



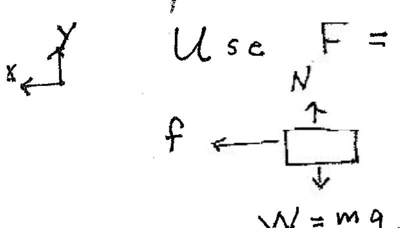
Get acceleration of bug – radial + tangential components

$$a_r = \frac{v^2}{R} = \omega^2 R$$
$$a_t = \alpha R$$

} components are at right angles

$$a = \sqrt{(\omega^2 R)^2 + (\alpha R)^2} = R\sqrt{\omega^4 + \alpha^2} \quad (1)$$

Use $F = ma$ with friction the horizontal force



y-problem: $N - mg = 0$, $N = mg$

$\Rightarrow f = \mu N = \mu mg$

x-problem

$F_x = f = ma = \mu mg$

$a = \mu g$ {mass cancels out} (2)

When a is large enough for (2) to be true, bug slips.

Put (1) into (2)

$R\sqrt{\omega^4 + \alpha^2} = \mu g \rightarrow$ solve for ω

$\sqrt{\omega^4 + \alpha^2} = \frac{\mu g}{R}$, squar both sides

$\omega^4 = \left(\frac{\mu g}{R}\right)^2 - \alpha^2$

$$\omega = \left[\left(\frac{\mu g}{R}\right)^2 - \alpha^2\right]^{1/4} = \left[\left(\frac{0.2 \times 9.8}{\{.25, .20, .15\}}\right)^2 - 1.5^2\right]^{1/4} = \left[\begin{matrix}59.2\\93.8\\168.\end{matrix}\ s^{-4}\right]^{1/4}$$

$$= \begin{Bmatrix}2.77\\3.11\\3.60\end{Bmatrix} s^{-1}$$

(cont.)

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Given ω, we get time from

$$\omega = \cancel{\omega_0} + \alpha t \quad (\omega_0 = 0)$$

$$t = \frac{\omega}{\alpha} = \frac{\begin{Bmatrix} 2.77 \\ 3.11 \\ 3.60 \end{Bmatrix} s^{-1}}{1.5\ s^{-2}} = \begin{Bmatrix} 1.85 \\ 2.07 \\ 2.40 \end{Bmatrix} s$$

Close, get nearly full credit,

You forgot a_r

(1) becomes

$$a = \omega^2 R$$

put into (2)

$$\omega^2 R = \mu g$$

$$\omega = \sqrt{\frac{\mu g}{R}} = \sqrt{\frac{.2 \cdot 9.8 \frac{m}{s^2}}{\begin{Bmatrix} 0.25 \\ 0.2 \\ 0.15 \end{Bmatrix} m}} = \begin{Bmatrix} 2.80 \\ 3.13 \\ 3.61 \end{Bmatrix} s^{-1}$$

$$t = \frac{\omega}{\alpha} = \frac{\begin{Bmatrix} 2.80 \\ 3.13 \\ 3.61 \end{Bmatrix} s^{-1}}{1.5\ s^{-2}} = \begin{Bmatrix} 1.87 \\ 2.09 \\ 2.41 \end{Bmatrix} s$$