Final
PH 241N

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Dec. 2005

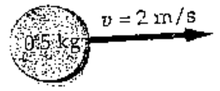
NAME ______________ ☐ Pledged SCORE____ / 100 pts

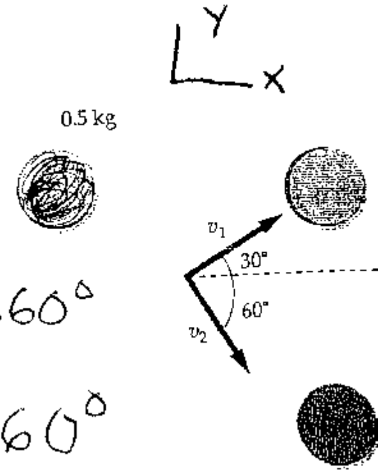
Remember to get full credit label answers with correct units, show all work, draw diagrams, give axis directions, write all applicable formuli.

1. [**12 pts**] A puck of mass .50 kg approaches a second similar puck that is stationary on frictionless ice.The initial speed of the moving puck is 2.0 m/s. After the collision, one puck leaves with a speed v_1 at 30^o to the original line of motion; the second puck leaves with speed v_2 at 60^o.

(A) Calculate v_1 and v_2

(B) Was the collision elastic?





A) cons. of momentum

① x: $m(2\,m/s) = mV_1\cos 30^\circ + mV_2\cos 60^\circ$

② y: $0 = mV_1\sin 30^\circ - mV_2\sin 60^\circ$

② $V_2 = V_1 \dfrac{\sin 30^\circ}{\sin 60^\circ} = .577V_1$ (plug into ①)

① $2\,m/s = V_1(.866) + (.577)(.5)V_1$

$V_1 = 1.73\,m/s$ $V_2 = 1.0\,m/s$ from ②

(B) $E_i = \frac{1}{2}(.5\,kg)(2\,m/s)^2 = 1.0\,J$

$E_f = \frac{1}{2}(.5\,kg)(1\,m/s)^2 + \frac{1}{2}(.5\,kg)(1.73\,m/s)^2$

$= 1.0\,J$ ✓

Yes, energy is also conserved

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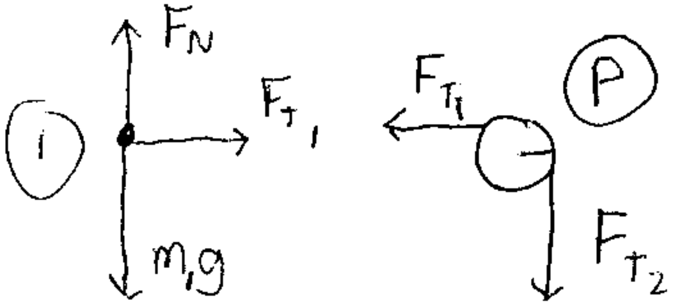
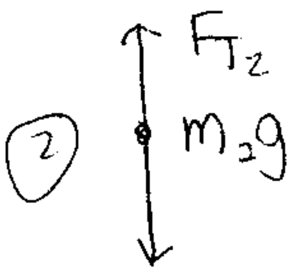
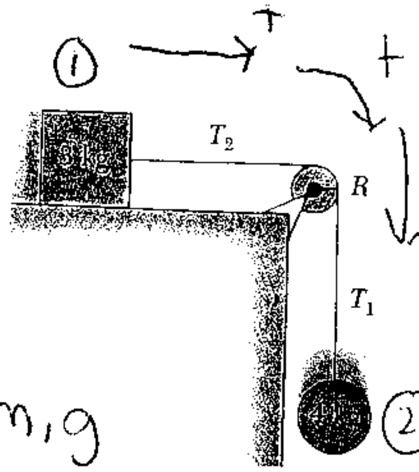
2. [14 pts] A 4-kg mass is connected by a massless cord to a 3 kg mass on a frictionless surface. The pulley rotates and has a moment of inertia of .5 kg m^2 and radius of .3 meters. Solve for the tensions in the rope and the acceleration of the system downward. **Remember to show force diagrams, torque diagrams, coordinate systems, and all equations.**

Remember to draw complete force and torque diagrams with directions defined, make equations and then solve.







(1) $m_1 a = F_{T_1}$
$0 = F_N - m_1 g$

(2) $m_2 a = m_2 g - F_{T_2}$

(P) $I \frac{a}{R} = R F_{T_2} - R F_{T_1}$

(1) $m_1 a = F_{T_1}$

(2) $m_2 a = m_2 g - F_{T_2}$

(P) $\frac{I a}{R^2} = F_{T_2} - F_{T_1}$

$a(m_1 + m_2 + I/R^2) = m_2 g$

so $a = \frac{m_2 g}{m_1 + m_2 + I/R^2}$

$= 2.3 m/s^2$

(1) $F_{T_1} = (4kg)(2.3 m/s^2)$

$F_{T_1} = 9.9 N$

(2) $F_{T_2} = m_2 g - m_2 a$

$F_{T_2} = 22.5 N$

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3. [12 pts] A solid cylinder of mass 2.5 kg and a radius of 12 cm is released from rest and **slips** down an incline at 30 degrees which is 40 meters tall. At the end of the incline there is 10 meters of level horizontal ground to a cliff edge. The moment of inertia of a solid cylinder is given as $\frac{1}{2}MR^2$. Assume that there is no kinetic friction in the problem.

(A) What is the speed of the cylinder as it leaves the cliff edge?

(B) What would be the speed of the cylinder as it leaves the cliff edge if it were able to **roll** down the incline?

(C) What is $KE_{(A)} - KE_{(B)}$?

(A) Energy conservation

$mgh = \frac{1}{2}mv^2$ (No rolling)

$v = \sqrt{2gh} = \sqrt{2g(40m)} = 28\,m/s$

(B) $mgh = \frac{1}{2}mv^2 + \frac{1}{2}(\frac{1}{2}mR^2)\omega^2 \qquad \omega = \frac{v}{R}$

$gh = \frac{1}{2}v^2 + \frac{1}{4}v^2$

$v = \sqrt{\frac{4}{3}g(40m)} = 23\,m/s$

c) $\frac{1}{2}(2.5kg)(28\,m/s)^2 - \frac{1}{2}(2.5kg)(23\,m/s)^2$

$= 320\,J$

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4. **[14 pts]** A child of mass 25 kg stands at the edge of a rotating platform of mass 150 kg and radius 4.0 meters. The platform, with the child on it, rotates with an angular speed of 6.25 rad/s. The child jumps off in the radial direction. Assume $I = \frac{1}{2}mR^2$ for the platform.

(A) The child-platform system experiences a total torque of zero. Why?

(B) What is the new angular speed of the platform after the child jumps off?

(C) If the child were to jump back on again in the same radial direction, what would be the new speed of the platform?

A) Radial Direction same as moment Arm. If same direction than no torque.

B) $L_i = L_f \quad I_p\omega + I_c\omega = I_p\omega'$

$\frac{1}{2}(150\,kg)(4\,m)^2(6.25\,\frac{rad}{s}) + (25\,kg)(4\,m)^2(6.25\,rad/s)$

$= (\frac{1}{2})(150\,kg)(4\,m)^2\omega$

$\omega = 8.33\ rad/s$

(C) Back to orig. 6.25 rad/s

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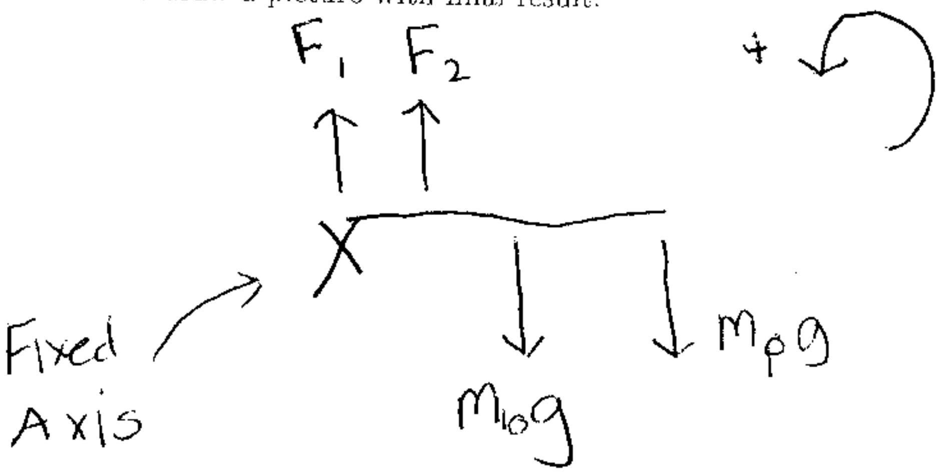
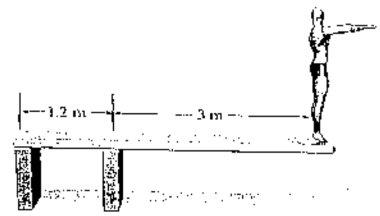
5. [14 pts] The diving board has a mass of 35 kg. Find the force on the supports when a 70 kg diver stands at the end of the diving board. The forces may be upward or downward so draw a picture with final result.





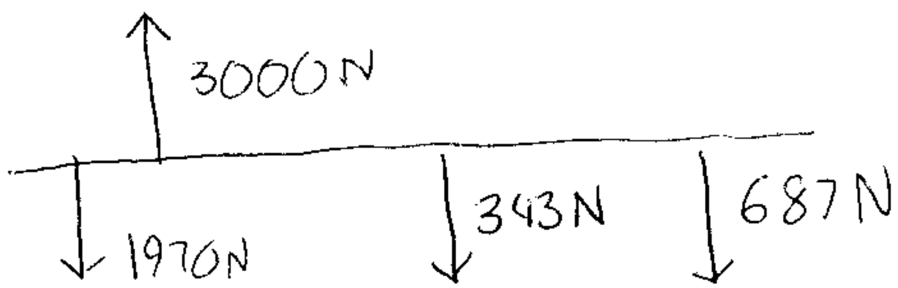
$$F_1 + F_2 - (35kg)(9.81m/s^2) - (70kg)(9.81m/s^2) = 0N$$

$$F_1 + F_2 = 1030N$$

$$\Sigma \tau = 0 = (1.2m)F_2 - (2.1m)(35kg)(9.81m/ - (4.2m)(70kg)(9.81m$$

$$\boxed{F_2 = 3000N}$$

$$F_1 = 1030N - 3000N = -1970N$$



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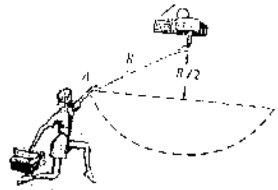
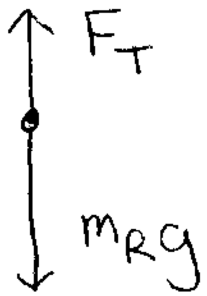
6. **[14 pts]** Red is a girl of mass m who is taking a picnic lunch to her grandmother. She ties a rope of length R to a tree branch over a creek and starts to swing from rest at point A, which is a distance $R/2$ lower than the branch. What is the minimum breaking tension for the rope if it is not to break and drop Red into the creek?

(A) Draw a force diagram for Red at the bottom of the circle

(C) Write down the total force equation from the picture.

(D) Solve for the value of the tension needed to support Red.





circular motion

$$\frac{m_R v^2}{R} = F_T - m_R g$$

Energy is conserved

$$mgh = \tfrac{1}{2} m v^2$$

$$\left(mg\,R/2\right) = \tfrac{1}{2} m v^2$$

$$v^2 = gR$$

so

$$m_R g = F_T - m_R g$$

$$\boxed{F_T = 2 m_R g}$$

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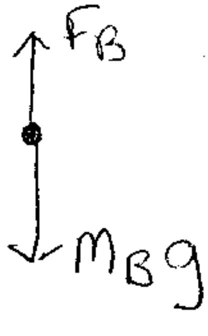
7. **[14 pts]** A block of wood of 1.5 kg mass floats on water with 68% of its volume submerged.

(A) Derive, using Archimedes principle, the density of wood. You should get $\rho_{wood} = 680 kg/m^3$.

(B) A lead block is placed on the wood and the wood sinks to 95% underwater. What is the mass of the lead block?

(A)



$= m/V$

$= \frac{m}{\rho}$

$F_B = m_B g$ $\rho_f = 1000 \frac{kg}{m^3}$

$F_B = \rho_f V_B (.68) g$

$m_B g = \rho_f V_B (.68) g$

$\rho_B V_B = \rho_f V_B (.68)$

$\rho_B = \rho_f (.68) = 680 kg/m^3$

(B) $m_B g + m_L g = F_B = \rho_f V_B (.95) g$

$1.5 kg + m_L = \left(\frac{1000 kg}{m^3}\right) \frac{m_B}{\rho_B} (.95)$

$m_L = .595 kg$

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8. [**12 pts**] An open-open tube of 155 cm has resonant frequencies of 315 Hz and 420 Hz (with none in between).

(A) What is the lowest resonant frequency?

(B) What is the wave speed?

(C) Draw a picture of the 315 Hz case and the 420 Hz case in a tube showing where the nodes and anti-nodes appear.

$L = \frac{n\lambda}{2}$ $n = 1, 2, 3, \ldots$

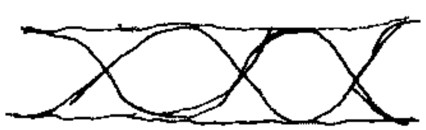
$\lambda = \frac{2L}{n}$

$V = f\lambda = \frac{f2L}{n}$ so $f = \frac{n}{2L} V = \frac{n}{3.1m} V$

$\Delta f = 105$ Hz

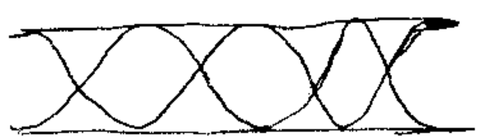
105 Hz, 210 Hz, 315 Hz, 420 Hz . . .

(B) $105 Hz = \left(\frac{1}{3.1m}\right) V$ so $V = 325 m/s$



315 Hz

$L = \frac{3}{2}\lambda$



$L = 2\lambda$