

Review ORIG

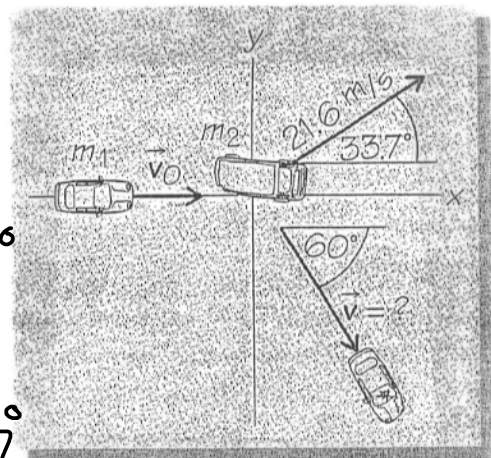
NAME _____ Pledged SCORE ___ / 100 pts

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

1. [14 pts] In a court hearing, a police expert reconstructs an accident in the following way: A sports car of mass $m_1 = 1000$ kg collided with a parked pickup truck of mass $m_2 = 1700$ kg. From the skid marks it was estimated that the speed of the pickup truck immediately after the collision was 21.6 m/s at an angle of 33.7° . The sports car left a mark at an angle of 60.0° , leaving the scene. What was the original and final speed of the sports car. Was the driver speeding (speed limit is 100 km/hr).

inelastic collision
momentum conservation

in 2 Dimensions



$$x: m_1 v_0 = m_1 v_1' \cos 60^\circ + m_2 (21.6 \text{ m/s}) \cos 33.7^\circ \quad (1)$$

$$y: 0 = -m_1 v_1' \sin 60^\circ + m_2 (21.6 \text{ m/s}) \sin 33.7^\circ \quad (2)$$

(2) solve for v_1'

$$v_1' = \frac{(1700 \text{ kg})(21.6 \text{ m/s}) \sin 33.7^\circ}{(1000 \text{ kg}) \sin 60^\circ} = 23.5 \text{ m/s}$$

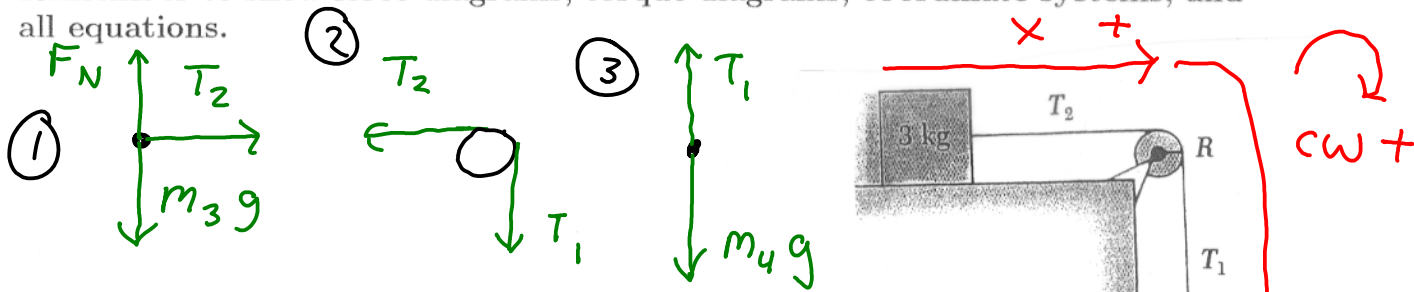
(1) now solve for v_0

$$v_0 = \frac{(1000 \text{ kg})(23.5 \text{ m/s}) \cos 60^\circ + (1700 \text{ kg})(21.6 \text{ m/s}) \cos 33.7^\circ}{(1000 \text{ kg})}$$

$$= 42.3 \text{ m/s}$$

$$(42.3 \text{ m/s}) \left(\frac{1 \text{ km}}{1000 \text{ m}} \right) \left(\frac{3600 \text{ s}}{1 \text{ hr}} \right) = 152 \text{ km/hr}$$

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 $.5 \text{ kg m}^2$ 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.



$$\textcircled{1} m_3 a = T_2 \quad \textcircled{2} I_P \alpha = R (T_1 - T_2)$$

$$\textcircled{4} \alpha = \frac{a}{R}$$

$$\textcircled{3} m_4 a = m_4 g - T_1$$

$$\textcircled{2} \frac{(.5 \text{ kg m}^2) a}{.3 \text{ m}^2} = T_1 - T_2$$

solve for T_1
using $\textcircled{3}$

$$\textcircled{2} \frac{.5 \text{ kg m}^2}{.3 \text{ m}^2} a = (4 \text{ kg})(9.8 \text{ m/s}^2) - (4 \text{ kg})a - (3 \text{ kg})a$$

$$\textcircled{2} a (1.667 \text{ kg} + 4 \text{ kg} + 3 \text{ kg}) = 39.2 \text{ N}$$

$$a = 4.5 \text{ m/s}^2$$

$$T_2 = (3 \text{ kg})a = (3 \text{ kg})(4.5 \text{ m/s}^2) = 13.6 \text{ N}$$

$$T_1 = (4 \text{ kg})(9.8 \text{ m/s}^2) - (4 \text{ kg})(4.5 \text{ m/s}^2) = 21.2 \text{ N}$$

3. [12 pts] A hollow uniform sphere ($I = mR^2$) and a solid uniform sphere of the same mass and radius ($I = \frac{2}{5}mR^2$) roll down an incline plane with the same height H without slipping. Each is moving horizontally as it leaves the ramp. Assume the range of the hollow sphere is L , find the range of the solid uniform sphere L' in terms of L ? Basically which one travels farther and by what percent?

Energy conservation - *static friction only*

TOP: PE \rightarrow conserved

Ramp: KE

$$mgh = \frac{1}{2}I\omega^2 + \frac{1}{2}mV^2$$

$$mgh = \frac{1}{2}I \frac{V^2}{R^2} + \frac{1}{2}mV^2$$

$$\text{so } V^2 = \frac{mgh}{\frac{1}{2}I/R^2 + \frac{1}{2}m}$$

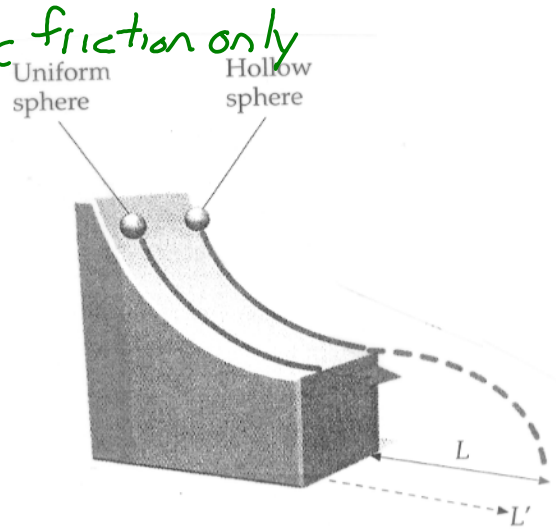
for hollow sphere $V^2 = \frac{mgh}{m} = gH$

for solid sphere $V^2 = \frac{mgh}{\frac{7}{10}m} = \frac{10}{7}gH$

they fall at same rate so time will be the same

$$\Delta X = V_{ox} t \quad \text{so } \frac{\Delta X_{\text{Hollow}}}{V_{ox \text{ Hollow}}} = \frac{\Delta X_{\text{solid}}}{V_{ox \text{ solid}}}$$

$$\frac{L}{\sqrt{gH}} = \frac{\Delta X_{\text{solid}}}{\sqrt{\frac{10}{7}gH}} \rightarrow \Delta X_{\text{solid}} = \frac{L \left(\sqrt{\frac{10}{7}gH} \right)}{\sqrt{gH}} = 1.2L$$



4. [9 pts] A cylinder with moment of inertia I_1 rotates with an angular velocity of ω_0 about a frictionless vertical axis. A second cylinder, with moment of inertia I_2 initially not rotating drops onto the first cylinder. Since the surfaces are rough, the two reach the same angular velocity ω .

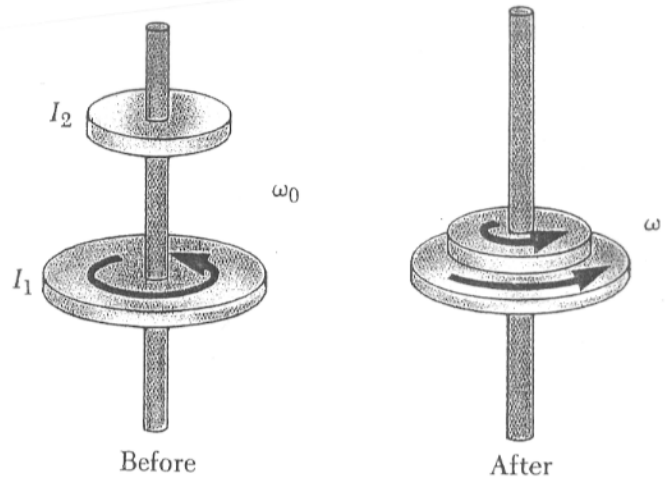
(a) Calculate ω in terms of the variables given

(b) Show that energy is not conserved in this process, where did the energy go?

L is conserved Before = After

$$I_1 \omega_0 = (I_1 + I_2) \omega$$

$$\omega = \frac{I_1 \omega_0}{I_1 + I_2}$$



$$E_B = \frac{1}{2} I_1 \omega_0^2$$

$$E_A = \frac{1}{2} (I_1 + I_2) \omega^2 = \frac{1}{2} (I_1 + I_2) \left(\frac{I_1 \omega_0}{I_1 + I_2} \right)^2$$

$$E_A = \frac{\frac{1}{2} I_1^2 \omega_0^2}{I_1 + I_2}$$

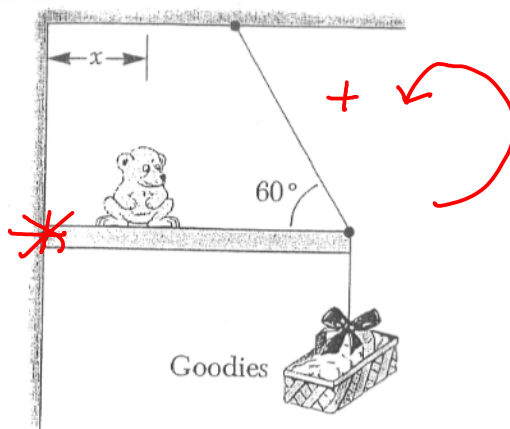
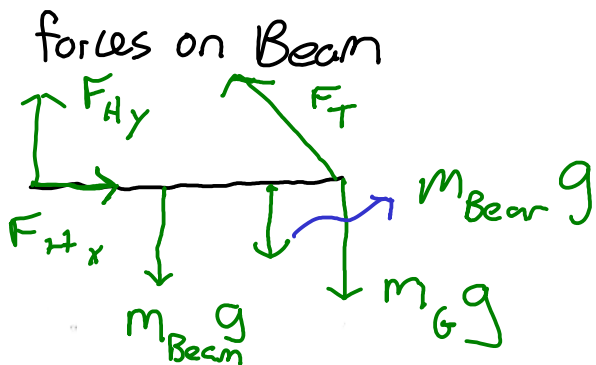
if $I_2 > 0$ $E_A < E_B$

Energy went to friction \rightarrow Rough surface
dissipated in collision

5. [14 pts] A hungry bear with a mass of 70 kg walks out on a beam in an attempt to retrieve some "Goodies" hanging at the end of the beam. The beam is 6.0 meters long and has a mass of 20 kg. The goodies weigh 9.0 kg. Unfortunately the wire snaps before the bear can get there. If the wire can only support 850 N how far from the wall does the wire snap and the bear fall.

Remember to draw force diagram for beam. There should be three unknowns: spot of bear, horizontal force on wall hinge, vertical force on wall hinge

solve for when $F_T = 850\text{N}$, one step further it breaks



The hinge is holding this in place and its force is adjustable and will not snap

$$\sum F = 0 \quad X: F_{Hx} - F_T \cos 60^\circ = 0\text{N} \quad (1)$$

$$Y: F_{Hy} + F_T \sin 60^\circ - g(m_{\text{Beam}} + m_{\text{Bear}} + m_G) = 0\text{N} \quad (2)$$

moment arm

$$\sum \tau = 0 \quad \tau = R F \sin \theta \quad \text{choose axis on Hinge}$$

$$(3) \quad (m_{\text{Beam}} g)(3\text{m}) - (m_{\text{Bear}} g)(R_{\text{Bear}}) - (m_G g)(6\text{m})$$

$$+ F_T (6\text{m}) \sin 60^\circ = 0$$

Notice smart choice of axis only need to solve torque eq. for R_{Bear}

$$(3) \quad (850\text{N})(6\text{m}) \sin 60^\circ - (20\text{kg})(9.8\text{m/s}^2)(3\text{m}) - (9\text{kg})(9.8\text{m/s}^2)(6\text{m}) = (70\text{kg})(9.8\text{m/s}^2) R_{\text{Bear}}$$

$$R_B = 4.8\text{m}$$

6. [14 pts] A character named Lou has set up a deceptive weightloss scam. The customer sits on a platform scale at the back of the van, and the scale reads 825 N while the van is at rest. Lou drives off at a constant 14m/s. Lou then asks the customer to think "heavy" as he drives through the bottom of a dip in the road having a radius of curvature of 80 meters.

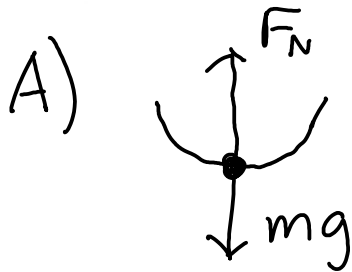
(A) What does the scale read now?

Then Lou goes over the top of a hill which also has a radius of curvature of 80 meters and tells the customer to think "light".

(B) What does the scale read now

Please show all work

→ what scale reads

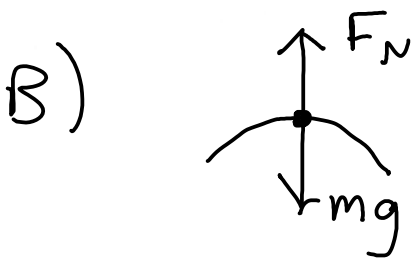


$$\frac{mv^2}{R} = \underline{F_N} - mg$$

$$m = 825 \text{ N} / g = 84.1 \text{ Kg}$$

$$\frac{(84.1 \text{ Kg})(14 \text{ m/s})^2}{80 \text{ m}} = F_N - 825 \text{ N}$$

$$F_N = 1030 \text{ N}!$$



$$\frac{mv^2}{R} = mg - F_N$$

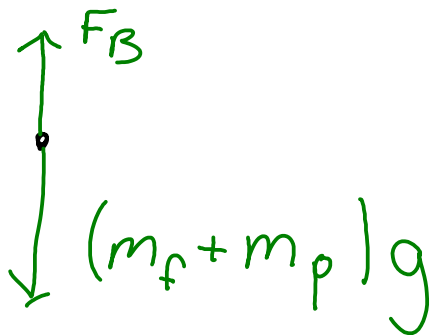
$$\frac{(84.1 \text{ Kg})(14 \text{ m/s})^2}{80 \text{ m}} = 825 \text{ N} - F_N$$

$$F_N = 619 \text{ N}$$

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7. [14 pts] A frog in a hemispherical pod is just floating without sinking in water. If the pod has a radius of .060 meters and a mass of 125 grams, what is the mass of the frog?

$$\rho = 998 \text{ kg/m}^3 \text{ for water} \quad V_{\text{pod}} = \frac{2}{3} \pi r^3.$$



$$F_B - (m_f + m_p)g = 0 \quad (1)$$

$$F_B = \rho_w V_{\text{pod}} g \quad V_{\text{pod}} = \frac{2}{3} \pi r^3 \quad (2)$$

$$\left(\frac{998 \text{ kg}}{\text{m}^3} \right) \left(\frac{2}{3} \pi (.060 \text{ m})^3 \right) (9.8 \text{ m/s}^2)$$

$$= (.125 \text{ kg}) (9.8 \text{ m/s}^2) + m_f (9.8 \text{ m/s}^2)$$

$$m_f = .326 \text{ kg}$$

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8. [9 pts] The range of human hearing is normally between 20 Hz and 20000 Hz.

(A) what is the length of an open-open organ pipe which has as its fundamental note 20 Hz? 20000 Hz?

~~(B) Do part (A) again but or an open-closed pipe~~

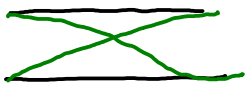
(C) Draw the standing wave for part (A) and (B)

Assume the velocity of sound in air is 335 m/s.

$$L = n\lambda \quad \lambda = \frac{v}{f} \quad \text{so } L = \frac{nv}{2f} \quad n = 1$$

$$L = \frac{335 \text{ m/s}}{2(20 \text{ Hz})} = 8.375 \text{ m}$$

$$L = \frac{335 \text{ m/s}}{2(20000 \text{ Hz})} = 0.008375 \text{ m} / \sim 8.37 \text{ mm.}$$

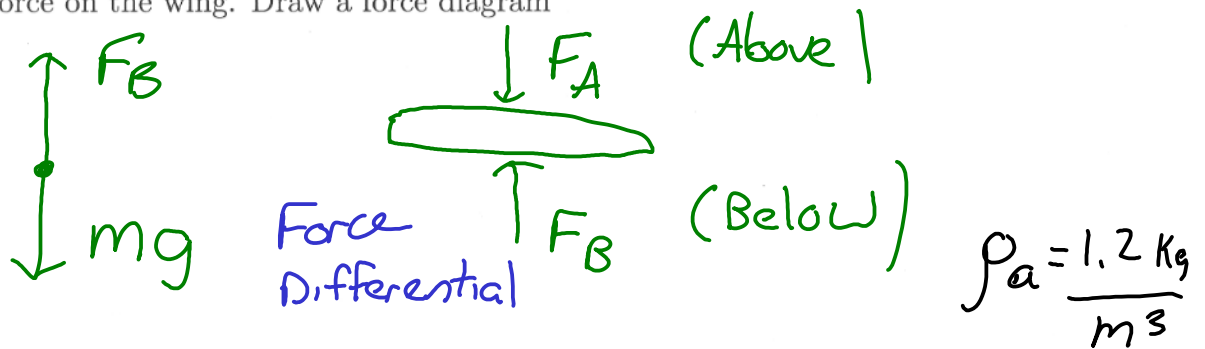


Not studied
in our class

formulas
are same

NAME _____

9. [9 pts] A small airplane has a total wingspan of 8.0m^2 . If the air flowing over the wing has a speed of 130 m/s and the air below the wing has a speed of 115 m/s , what is the net force on the wing. Draw a force diagram



$$P_A + \frac{1}{2} \rho_a V_A^2 + \cancel{\rho_a g h_A} = P_B + \frac{1}{2} \rho_a V_B^2 + \cancel{\rho_a g h_B}$$

$h_A \approx h_B$

$$P_B - P_A = \frac{1}{2} \rho_a V_A^2 - \frac{1}{2} \rho_a V_B^2$$

$$P_B - P_A = \frac{1}{2} (1.2 \text{ Kg/m}^3) \left((130)^2 - (115)^2 \right) \text{ m}^2/\text{s}^2$$

$$= 2205 \text{ Pa}$$

$$\Delta P = \Delta F A$$

$$2205 \text{ Pa} = \Delta F (8\text{m}^2)$$

$$\Delta F = 275.6 \text{ N up}$$