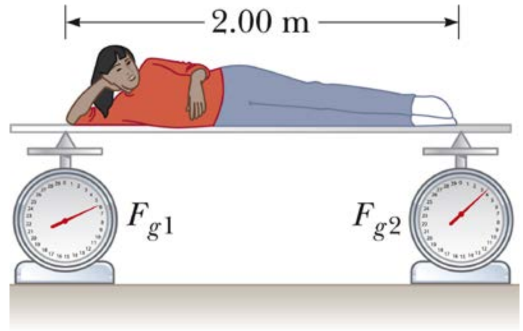
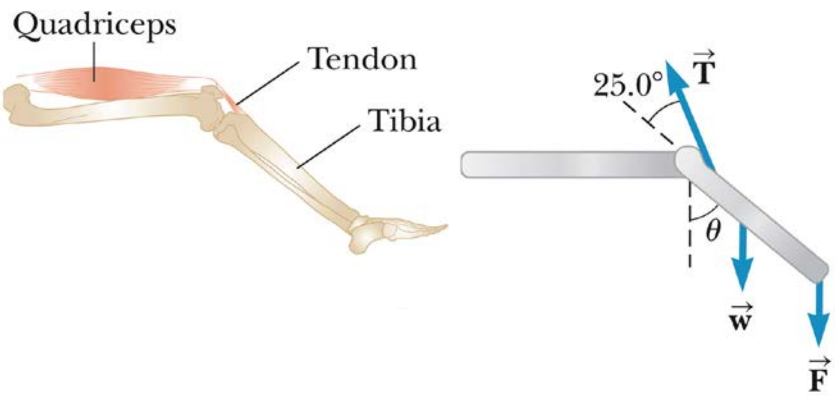
Physics 117.3 Tutorial #1 – January 14 to 25, 2013

Rm 130 Physics

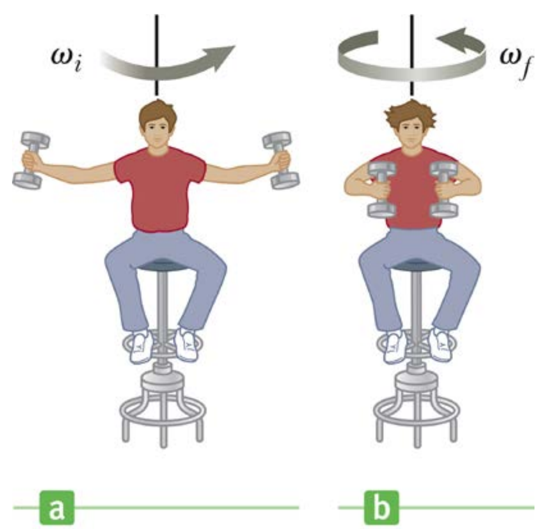
8.79. The location of a person's centre of gravity can be determined using the arrangement shown in the figure. A light plank rests on two scales that read F_{g1} = 380 N and F_{g2} = 320 N. The scales are separated by a distance of 2.00 m. How far from the woman's feet is her centre of gravity?



8.29 The large quadriceps muscle in the upper leg terminates at its lower end in a tendon attached to the upper end of the tibia. The forces on the lower leg when the leg is extended are modeled as in the figure. **T** is the force of tension in the tendon, **w** is the force of gravity acting on the lower leg, and **F** is the force of gravity acting on the foot. Find T when the tendon is at an angle of 25.0° with the tibia, assuming that w = 30.0 N, F = 12.5 N, and the leg is extended at an angle θ of 40.0° with the vertical. Assume that the centre of gravity of the lower leg is at its centre and that the tendon attaches to the lower leg at a point one-fifth of the way down the leg.



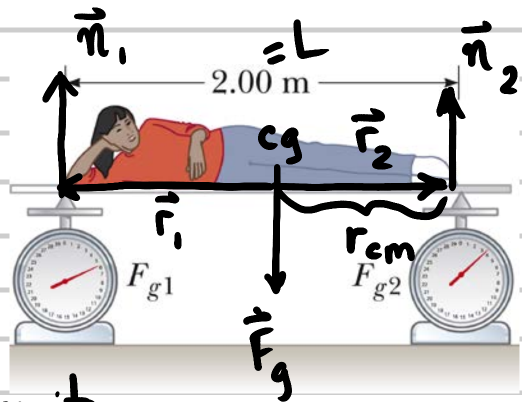
8.62. A student sits on a rotating stool holding two 3.0-kg objects. When his arms are extended horizontally, the objects are 1.0 m from the axis of rotation and he rotates with an angular speed of 0.75 rad/s. The moment of inertia of the student plus stool is 3.0 kg·m^2 and is assumed constant. The student then pulls in the objects horizontally to 0.30 m from the rotation axis. (a) Find the new angular speed of the student. (b) Find the kinetic energy of the system (student + stool + objects) before and after the objects are pulled in.



Physics 117.3 Tutorial #1 – January 14 to 25, 2013

Rm 130 Physics

8.79. The location of a person's centre of gravity can be determined using the arrangement shown in the figure. A light plank rests on two scales that read F_{g1} = 380 N and F_{g2} = 320 N. The scales are separated by a distance of 2.00 m. How far from the woman's feet is her centre of gravity?



The woman's weight, $\vec{F}_g$, acts at her centre of gravity.

$$F_g = F_{g_1} + F_{g_2} = 380\text{N} + 320\text{N} = 700\text{N}$$

Choose the centre of gravity as the axis of rotation. The woman is in equilibrium, so

$$\Sigma \vec{\tau} = 0 \Rightarrow \tau_{n_1} + \tau_{F_g} + \tau_{n_2} = 0$$

$$-r_1 n_1 \sin 90° + 0 + r_2 n_2 \sin 90° = 0$$

$$r_2 n_2 = r_1 n_1$$

From the diagram, $r_2 = r_{cm}$ and $r_1 = L - r_{cm}$

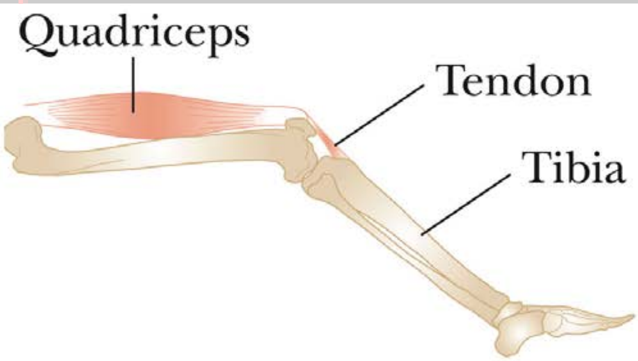
$$\therefore \quad r_{cm} n_2 = (L - r_{cm}) n_1$$

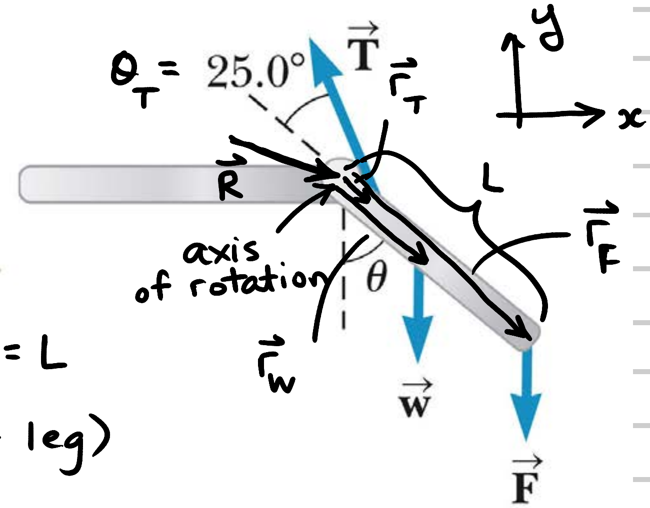
$$r_{cm} n_2 = L n_1 - r_{cm} n_1$$

$$r_{cm}(n_2 + n_1) = L n_1 \Rightarrow r_{cm} = \frac{L n_1}{(n_2 + n_1)}$$

$$r_{cm} = \frac{(2.00\text{m})(380\text{N})}{(320\text{N} + 380\text{N})} = 1.09\text{m}$$ from feet to centre of gravity

8.29 The large quadriceps muscle in the upper leg terminates at its lower end in a tendon attached to the upper end of the tibia. The forces on the lower leg when the leg is extended are modeled as in the figure. **T** is the force of tension in the tendon, **w** is the force of gravity acting on the lower leg, and **F** is the force of gravity acting on the foot. Find T when the tendon is at an angle of 25.0° with the tibia, assuming that w = 30.0 N, F = 12.5 N, and the leg is extended at an angle θ of 40.0° with the vertical. Assume that the centre of gravity of the lower leg is at its centre and that the tendon attaches to the lower leg at a point one-fifth of the way down the leg.





$r_T = \frac{1}{5}L$; $r_w = \frac{1}{2}L$; $r_F = L$

(L = length of lower leg)

Note that there is a force $\vec{R}$ exerted by the femur on the lower leg at the knee joint.

The lower leg is in equilibrium. Take the knee joint as the axis of rotation.

$$\sum \vec{\tau} = 0 \Rightarrow \vec{\tau}_R + \vec{\tau}_T + \vec{\tau}_w + \vec{\tau}_F = 0$$

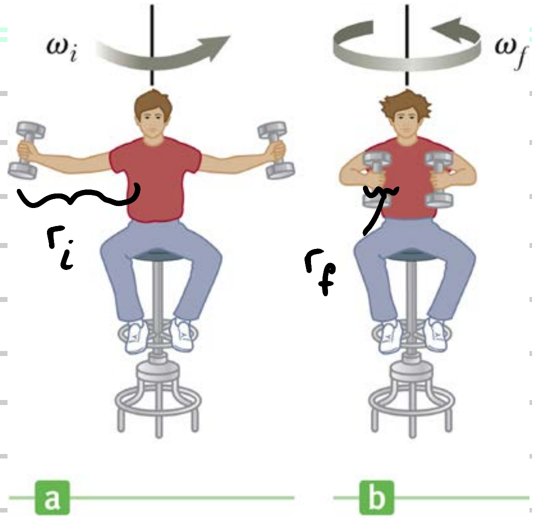
$$0 + r_T T \sin\theta_T - r_w w \sin\theta - r_F F \sin\theta = 0$$

$$r_T T \sin\theta_T = (r_w w + r_F F)\sin\theta$$

$$T = \frac{(r_w w + r_F F)\sin\theta}{r_T \sin\theta_T} = \frac{\left[(\frac{1}{2}L)(30.0\text{N}) + (L)(12.5\text{N})\right]\sin 40.0^\circ}{\frac{1}{5}L \sin 25.0^\circ}$$

$$T = 209\text{N}$$

8.62. A student sits on a rotating stool holding two 3.0-kg objects. When his arms are extended horizontally, the objects are 1.0 m from the axis of rotation and he rotates with an angular speed of 0.75 rad/s. The moment of inertia of the student plus stool is 3.0 kg·m^2 and is assumed constant. The student then pulls in the objects horizontally to 0.30 m from the rotation axis. (a) Find the new angular speed of the student. (b) Find the kinetic energy of the system (student + stool + objects) before and after the objects are pulled in.



(a) Assuming that the stool can rotate without friction,

$\sum \vec{\tau} = 0$ and $\therefore$ Angular momentum is conserved.

$$L_f = L_i \Rightarrow I_f \omega_f = I_i \omega_i$$

$I = I_{ss} + I_{obj_1} + I_{obj_2}$; ss = student + stool

$$I_f = I_{ss} + 2m_{obj} r_f^2 \quad ; \quad I_i = I_{ss} + 2m_{obj} r_i^2$$

$$I_f = 3.0\ \text{kg}\cdot\text{m}^2 + 2(3.0\ \text{kg})(0.30\ \text{m})^2 = 3.54\ \text{kg}\cdot\text{m}^2$$

$$I_i = 3.0\ \text{kg}\cdot\text{m}^2 + 2(3.0\ \text{kg})(1.0\ \text{m})^2 = 9.0\ \text{kg}\cdot\text{m}^2$$

$$\omega_f = \frac{I_i \omega_i}{I_f} = \frac{(9.0\ \text{kg}\cdot\text{m}^2)(0.75\ \text{m/s})}{3.54\ \text{kg}\cdot\text{m}^2} = 1.9\ \text{rad/s}$$

(b) $$KE_i = \frac{1}{2} I_i \omega_i^2 = \frac{1}{2}(9.0\ \text{kg}\cdot\text{m}^2)(0.75\ \text{rad/s})^2 = 2.5\ \text{J}$$

$$KE_f = \frac{1}{2} I_f \omega_f^2 = \frac{1}{2}(3.54\ \text{kg}\cdot\text{m}^2)(1.9\ \text{rad/s})^2 = 6.4\ \text{J}$$

The increase in KE occurs due to the work done by the student when pulling the objects closer to the axis of rotation.

Physics 117.3 Tutorial #2 – January 28 to February 8, 2013

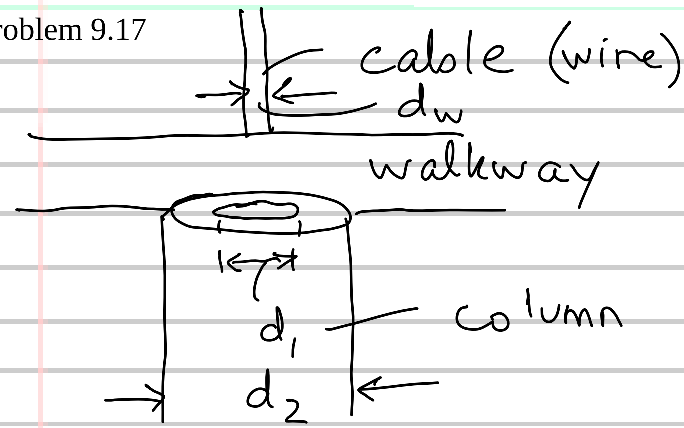
Rm 130 Physics

1. Problem 9.17 A walkway suspended across a hotel lobby is supported at numerous points along its edges by a vertical cable above each point and a vertical column underneath. The steel cable is 1.27 cm in diameter and is 5.75 m long before loading. The aluminum column is a hollow cylinder with an inside diameter of 16.14 cm, an outside diameter of 16.24 cm, and unloaded length of 3.25 m. When the walkway exerts a load force of 8500 N on one of the support points, how much does the point move down?

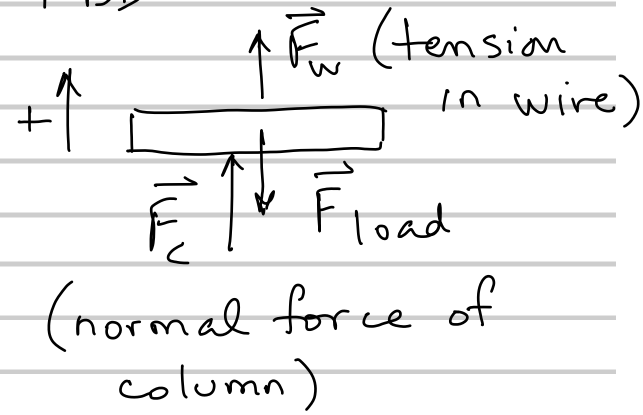
2. A block of wood, with density 780 kg/m^3, has a cubic shape with sides 0.330 m long. The wood is placed in water and a rope of negligible mass is used to tie a piece of lead to the bottom of the wood. The lead pulls the wood into the water until it is just completely covered with water. What is the mass of the lead? The density of lead is 11.3×10^3 kg/m^3. [Hint: Remember to consider the buoyant forces on both the wood and the lead.]

3. A house with its own well has a pump in the basement with an output pipe of inner radius 6.3 mm. Assume that the pump can maintain a gauge pressure of 410 kPa in the output pipe. A showerhead on the second floor (6.7 m above the pump's output pipe) has 36 holes, each of radius 0.33 mm. The shower is on "full blast" and no other faucet in the house is open. (a) Ignoring viscosity, with what speed does water leave the showerhead? (b) With what speed does water move through the output pipe of the pump?

Problem 9.17



FBD:



After the cable has stretched and the column has compressed, the walkway is in equilibrium.

$$\sum \vec{F} = 0 \Rightarrow F_w + F_c - F_{load} = 0$$

Note that for the wire:

$$\frac{F_w}{A_w} = Y_{steel} \frac{\Delta L_w}{L_{ow}}$$

and for the column:

$$\frac{F_c}{A_c} = Y_{aluminum} \frac{\Delta L_c}{L_{oc}}$$

and $\Delta L_w = \Delta L_c$ (the amount that the wire stretches is the same as the amount that the column compresses)

From $F_w + F_c - F_{load} = 0$,

$$A_w Y_{steel} \frac{\Delta L}{L_{ow}} + A_c Y_{Al} \frac{\Delta L}{L_{oc}} - F_{load} = 0$$

$$A_w = \pi \left(\frac{d_w}{2}\right)^2 = \pi \left(\frac{0.0127\,m}{2}\right)^2 = 1.267 \times 10^{-4}\,m^2$$

$$A_c = \pi \left(\frac{d_2}{2}\right)^2 - \pi \left(\frac{d_1}{2}\right)^2 = \frac{\pi}{4}\left((0.1624\,m)^2 - (0.1614\,m)^2\right)$$

$$A_c = 2.543 \times 10^{-4}\,m^2$$

$$\Delta L \left(\frac{A_w Y_{steel}}{L_{ow}} + \frac{A_c Y_{Al}}{L_{oc}}\right) = F_{load}$$

$$\Delta L = \frac{F_{load}}{\left(\frac{A_w Y_{steel}}{L_{ow}} + \frac{A_c Y_{Al}}{L_{oc}}\right)}$$

$$\Delta L = \frac{8500\,N}{\left[\frac{(1.267 \times 10^{-4}\,m^2)(20 \times 10^{10}\,Pa)}{5.75\,m} + \frac{(2.543 \times 10^{-4}\,m^2)(7.0 \times 10^{10}\,Pa)}{3.25\,m}\right]}$$

$$\Delta L = 8.60 \times 10^{-4}\,m = 0.860\,mm$$

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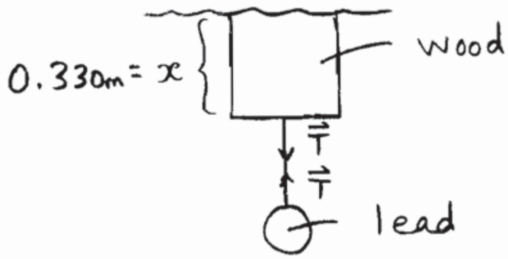
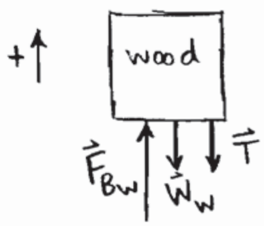
2.



The system is in equilibrium.

$\therefore \sum \vec{F} = 0$

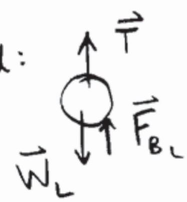
Consider the wood and lead separately.



$$\sum \vec{F} = 0 \Rightarrow F_{B_W} - W_W - T = 0$$

$$\underbrace{\rho_f}_{\text{fluid}} g V_W - \underbrace{\rho_W}_{\text{wood}} g V_W - T = 0 \quad ① \quad (V_{wood} = V_{water} \text{ since completely submerged})$$

Lead:



$$\sum \vec{F} = 0 \Rightarrow T + F_{B_L} - W_L = 0$$

$$T + \rho_f g V_L - \underbrace{m_L}_{\text{Lead}} g = 0 \quad ②$$

Solve ① for T and substitute into ②

$$\rho_f \cancel{g} V_W - \rho_W \cancel{g} V_W + \rho_f \cancel{g} V_L - m_L \cancel{g} = 0$$

note that $V_L = \dfrac{m_L}{\rho_L}$

$$\rho_f V_W - \rho_W V_W + \rho_f \frac{m_L}{\rho_L} - m_L = 0$$

$$\rho_f V_W - \rho_W V_W = m_L \left(1 - \frac{\rho_f}{\rho_L}\right)$$

$$m_L = \frac{V_W(\rho_f - \rho_W)}{(1 - \rho_f/\rho_L)} = \frac{(0.330\,\text{m})^3 (1000\,\text{kg/m}^3 - 780\,\text{kg/m}^3)}{\left(1 - \dfrac{1000\,\text{kg/m}^3}{11,300\,\text{kg/m}^3}\right)}$$

$$m_L = 8.67\,\text{kg}$$

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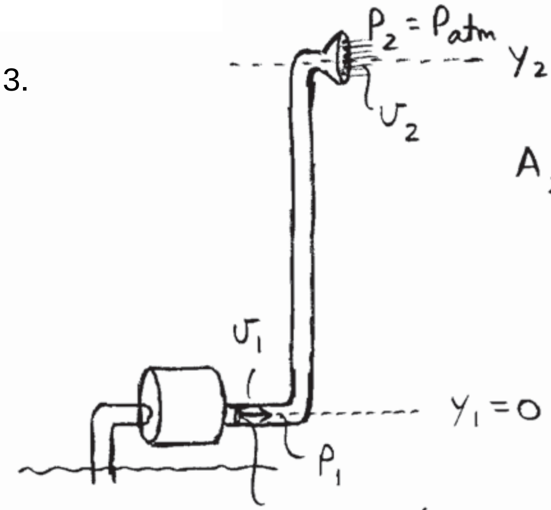
3.



Given $P_1 - P_{atm} = 410\,kPa$

$$A_2 = 36\left(\pi (0.00033m)^2\right) = 1.232\times10^{-5}m^3$$

Told to ignore viscosity, so we can use Bernoulli's.

Also, from continuity eq'n for an incompressible fluid,

$$A_1 = \pi(0.0063m)^2 = 1.247\times10^{-4}m^3 \qquad A_1 v_1 = A_2 v_2$$

$$P_1 + \tfrac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \tfrac{1}{2}\rho v_2^2 + \rho g y_2$$

(a) $$P_1 + \tfrac{1}{2}\rho\left(\frac{A_2 v_2}{A_1}\right)^2 + \rho g y_1 = P_{atm} + \tfrac{1}{2}\rho v_2^2 + \rho g y_2$$

$$P_1 - P_{atm} + \rho g(0) - \rho g y_2 = \tfrac{1}{2}\rho\left(v_2^2 - \left(\frac{A_2 v_2}{A_1}\right)^2\right)$$

$$(P_1 - P_{atm}) - \rho g y_2 = \tfrac{1}{2}\rho\left(1 - \frac{A_2^2}{A_1^2}\right) v_2^2$$

$$v_2 = \left[\frac{(P_1 - P_{atm}) - \rho g y_2}{\tfrac{1}{2}\rho\left(1 - \frac{A_2^2}{A_1^2}\right)}\right]^{1/2} = \sqrt{\frac{410\times10^3 Pa - (1000\,kg/m^3)(9.80\,m/s^2)(6.7m)}{\tfrac{1}{2}\left(1000\,\frac{kg}{m^3}\right)\left(1 - \frac{(1.232\times10^{-5}m^3)^2}{(1.247\times10^{-4}m^3)^2}\right)}}$$

$$v_2 = 26.37\,m/s = 26\,m/s$$

(b) $$v_1 = \frac{A_2 v_2}{A_1} = \frac{(1.232\times10^{-5}m^3)(26.37\,m/s)}{1.247\times10^{-4}\,m^3} = 2.6\,m/s$$

Physics 117.3 Tutorial #3 – February 11 to March 1, 2013

Rm 130 Physics

1. Problem 13.25 A vertical spring stretches 3.9 cm when a 10-g object is hung from it. The object is replaced with a block of mass 25 g that oscillates up and down in simple harmonic motion. Calculate the period of the motion.

2. Problem 13.55 A simple pendulum consists of a ball of mass 5.00 kg hanging from a uniform string of mass 0.0600 kg and length L. If the period of oscillation of the pendulum is 2.00 s, determine the speed of a transverse wave in the string when the pendulum hangs vertically.

3. Problem 14.17 There is evidence that elephants communicate via infrasound, generating rumbling vocalizations as low as 14 Hz that can travel up to 10 km. The intensity level of these sounds can reach 103 dB, measured a distance of 5.0 m from the source. Determine the intensity level of the infrasound 10 km from the source, assuming that the sound energy radiates uniformly in all directions.

Physics 117.3 Tutorial #3 – February 11 to March 1, 2013

Rm 130 Physics

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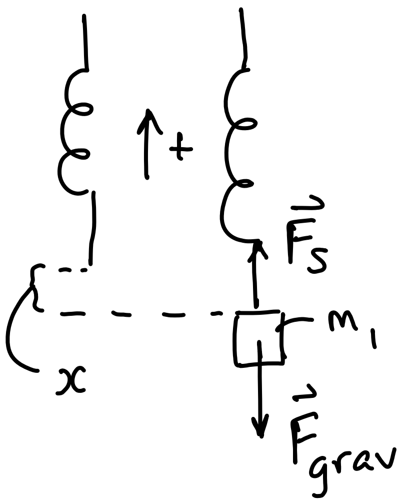
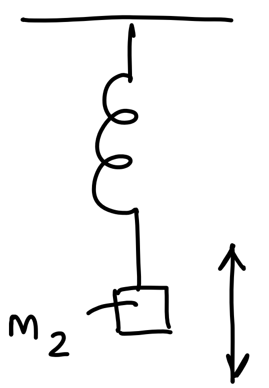


The 10g mass reaches equilibrium when the spring has stretched 3.9 cm

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

$$F_s - F_{grav} = 0$$

$$kx - m_1 g = 0 \Rightarrow k = \frac{m_1 g}{x}$$



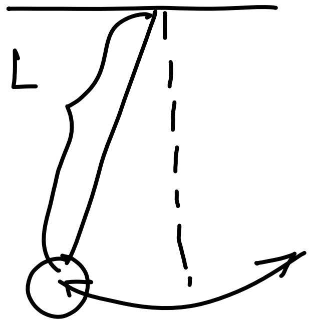
$$\omega = 2\pi f = \frac{2\pi}{T} = \sqrt{\frac{k}{m}}$$

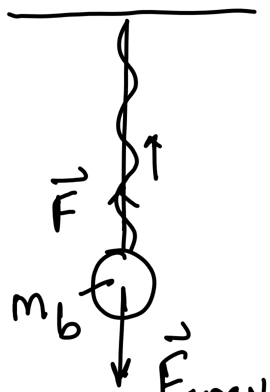
$$T = 2\pi\sqrt{\frac{m_2}{k}} = 2\pi\sqrt{\frac{m_2}{m_1 g/x}}$$

$$T = 2\pi\sqrt{\frac{m_2 x}{m_1 g}} = 2\pi\sqrt{\frac{(25\,g)(0.039\,m)}{(10\,g)(9.80\,m/s^2)}}$$

$$T = 0.63\,s$$

2. Problem 13.55 A simple pendulum consists of a ball of mass 5.00 kg hanging from a uniform string of mass 0.0600 kg and length L. If the period of oscillation of the pendulum is 2.00 s, determine the speed of a transverse wave in the string when the pendulum hangs vertically.





Tension F in the string is determined from $\Sigma \vec{F} = 0$

$$F - F_{grav} = 0$$

$$F = m_b g$$

Period, $T = 2\pi\sqrt{\frac{L}{g}}$

$$T^2 = \frac{4\pi^2 L}{g}$$

$$L = \frac{gT^2}{4\pi^2}$$

wave speed, $v = \sqrt{F/\mu}$

where $\mu = \frac{m_s}{L}$

$$v = \sqrt{\frac{m_b g}{m_s/L}} = \sqrt{\frac{m_b g L}{m_s}}$$

$$v = \sqrt{\frac{m_b g \cdot gT^2}{4\pi^2 m_s}} = \sqrt{\frac{m_b g^2 T^2}{4\pi^2 m_s}} = \frac{gT}{2\pi}\sqrt{\frac{m_b}{m_s}}$$

$$v = \frac{(9.80\,\mathrm{m/s^2})(2.00\,\mathrm{s})}{2\pi}\sqrt{\frac{5.00\,\mathrm{kg}}{0.0600\,\mathrm{kg}}} = 28.5\,\mathrm{m/s}$$

3. Problem 14.17 There is evidence that elephants communicate via infrasound, generating rumbling vocalizations as low as 14 Hz that can travel up to 10 km. The intensity level of these sounds can reach 103 dB, measured a distance of 5.0 m from the source. Determine the intensity level of the infrasound 10 km from the source, assuming that the sound energy radiates uniformly in all directions.

$\therefore I \propto \frac{1}{r^2}$. $\quad \beta = 10 \log(I/I_0)$

$\beta_1 = 103\,dB, \quad I_1 = ?, \quad r_1 = 5.0\,m$

$\beta_2 = ?, \quad I_2 = ?, \quad r_2 = 10\,km$

$$\frac{\beta}{10} = \log(I/I_0) \Rightarrow 10^{\beta/10} = \frac{I}{I_0} \Rightarrow I = I_0 10^{\beta/10}$$

$$\therefore I_1 = I_0 10^{103/10} = 1.00 \times 10^{-12}\,W/m^2 \cdot 10^{10.3}$$

$$I_1 = 0.020\,W/m^2$$

Power = IA = constant. $I_1 \cdot 4\pi r_1^2 = I_2 \cdot 4\pi r_2^2$

$$I_2 = \frac{I_1 r_1^2}{r_2^2} = \left(0.020\,\frac{W}{m^2}\right)\left(\frac{5.0\,m}{10 \times 10^3\,m}\right)^2 = 4.99 \times 10^{-9}\,\frac{W}{m^2}$$

$$\beta_2 = 10 \log\left(\frac{I_2}{I_0}\right)$$

$$\beta_2 = 10 \log\left(\frac{4.99 \times 10^{-9}\,W/m^2}{1.00 \times 10^{-12}\,W/m^2}\right) = 37\,dB$$

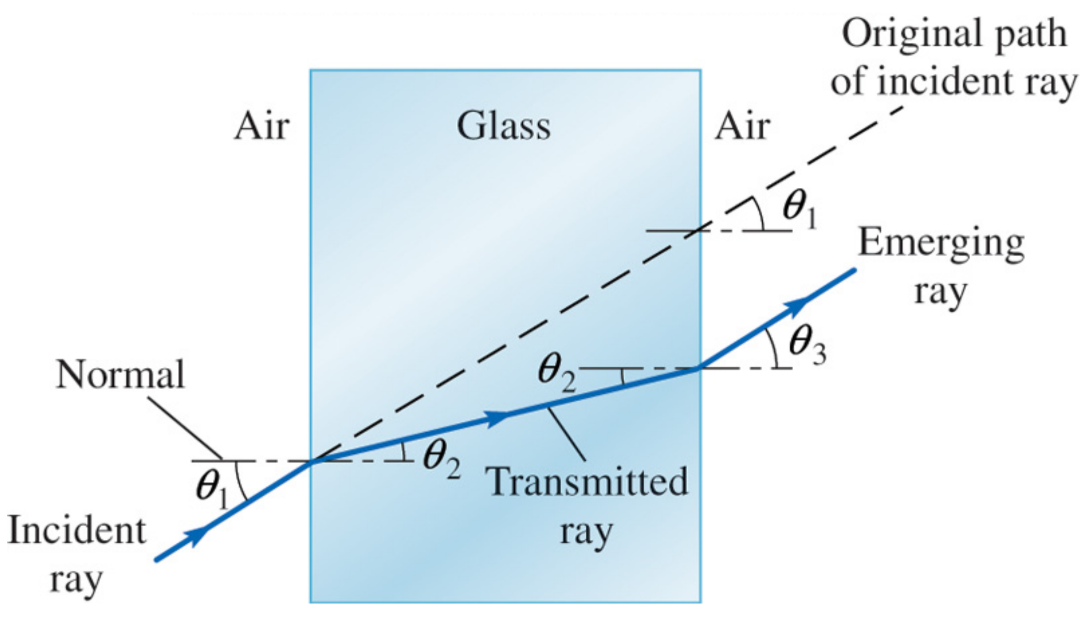
Physics 117.3 Tutorial #4 – March 4 to 15, 2013

Rm 130 Physics

Q1. A harpsichord string is made of yellow brass (Young's modulus 9.0×10^{10} Pa, tensile strength 6.3×10^{8} Pa, mass density 8500 kg/m^3). When tuned correctly, the tension in the string is 59.4 N, which is 93% of the maximum tension that the string can endure without breaking. The length of the string that is free to vibrate is 9.4 cm. What is the fundamental frequency of vibration of the string?

Q2. The pitch of the sound from a race car engine drops the musical interval of a fourth when it passes the spectators. This means the frequency of the sound after passing is 0.75 times what it was before. How fast is the race car moving? Assume that the speed of sound is 343 m/s.

Q3. A ray of light passes from air through a sheet of dense flint glass (n = 1.655) and then back into air. The angle of incidence on the first glass surface is 60.0°. The thickness of the glass is 5.00 mm; its front and back surfaces are parallel. How far is the ray displaced as a result of travelling through the glass? (i.e. What is the **<u>perpendicular</u>** distance between the outgoing ray leaving the glass and the extension of the original ray before it entered the glass?)



1.

$F = \text{tension} = 59.4\,N$

$L = 9.4\,cm = 0.094\,m$

$\rho = 8500\,kg/m^3$

At fundamental freq'y, $L = \frac{1}{2}\lambda_1 \Rightarrow \lambda_1 = 2L$

$$f_1 = \frac{v}{\lambda_1} = \frac{1}{\lambda_1}\sqrt{F/\mu} = \frac{1}{2L}\sqrt{\frac{F}{\mu}}$$

Recall that $\text{stress} = \frac{F}{A}$

TS = tensile strength = max. stress = $\frac{F_{max}}{A}$

We are told that $F = 93\%$ of F_{max} and that the tensile strength is $6.3 \times 10^8\,Pa$.

$$\therefore \quad TS = \frac{F_{max}}{A} = \frac{F/0.93}{A} \Rightarrow A = \frac{F}{0.93\,TS}$$

Let m = mass of string $= \rho V = \rho A L$

$$\therefore \mu = \frac{m}{L} = \rho A = \rho\left(\frac{F}{0.93\,TS}\right)$$

So...

$$f_1 = \frac{1}{2L}\sqrt{\frac{F}{\rho\left(\frac{F}{0.93\,TS}\right)}} = \frac{1}{2L}\sqrt{\frac{0.93\,TS}{\rho}}$$

$$f_1 = \frac{1}{2(0.094\,m)}\sqrt{\frac{(0.93)(6.3\times10^8\,Pa)}{8500\,kg/m^3}} = \boxed{1.4 \times 10^3\,Hz}$$

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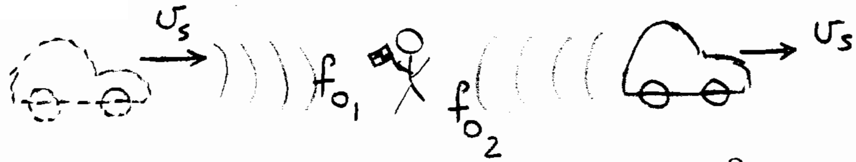
DATE

2.



Given that $f_{o_2} = 0.75 f_{o_1} \Rightarrow \dfrac{f_{o_2}}{f_{o_1}} = 0.75$

Let f_s be the freq'y of the engine sound, and $|v_s|$ be the speed of the race car.

$$f_{o_1} = \left(\frac{v}{v-(|v_s|)}\right) f_s \quad \text{and} \quad f_{o_2} = \left(\frac{v}{v-(-|v_s|)}\right) f_s$$

$$\frac{f_{o_2}}{f_{o_1}} = \frac{\left(\frac{v}{v+|v_s|}\right) f_s}{\left(\frac{v}{v-|v_s|}\right) f_s} = \frac{(v-|v_s|)}{(v+|v_s|)} = 0.75$$

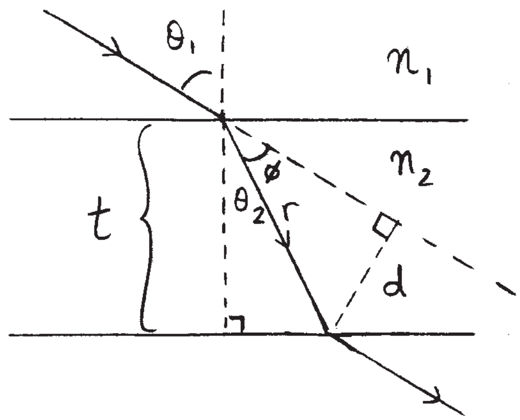
$$v - |v_s| = 0.75v + 0.75|v_s|$$

$$0.25v = 1.75|v_s|$$

$$|v_s| = \frac{0.25v}{1.75}$$

$$|v_s| = \frac{0.25(343\,m/s)}{1.75} = 49\,m/s \quad \left(\sim 180\,\frac{km}{h}\right)$$

3.



$n_1 = 1.000$ (air)

$n_2 = 1.655$ (dense flint glass)

$t = 5.00$ mm

$\theta_1 = 60.0^\circ$

Let r = length of light path in glass.

$$\cos\theta_2 = \frac{t}{r} \Rightarrow r = \frac{t}{\cos\theta_2}$$

From the diagram, $d = r\sin\phi$ where $\phi = \theta_1 - \theta_2$.

$\therefore$ Use Snell's Law to determine θ_2.

$$n_1 \sin\theta_1 = n_2 \sin\theta_2 \Rightarrow \theta_2 = \arcsin\left(\frac{n_1 \sin\theta_1}{n_2}\right)$$

$$\theta_2 = \arcsin\left(\frac{1.000 \sin(60.0^\circ)}{1.655}\right) = 31.55^\circ$$

$$\phi = 60.0^\circ - 31.55^\circ = 28.45^\circ$$

$$d = r\sin\phi = \frac{t}{\cos\theta_2} \cdot \sin\phi$$

$$d = \frac{5.00 \text{ mm}}{\cos(31.55^\circ)} \cdot \sin(28.45^\circ) = 2.80 \text{ mm}$$

Physics 117.3 Tutorial #5 – March 18 to 28, April 5, 2013

Rm 130 Physics

1. Two lenses, separated by a distance of 21.0 cm, are used in combination. The first lens has a focal length of +30.0 cm; the second has a focal length of –15.0 cm. An object, 2.0 mm long, is placed 1.8 cm before (in front of) the first lens. (a) What are the intermediate and final image distances relative to the corresponding lenses? (b) What is the total magnification? (c) What is the height of the final image?

2. White light containing wavelengths from 400 nm to 700 nm is shone through a grating. Assuming that at least part of the 3rd-order spectrum is present, show that the 2nd- and 3rd-order spectra always overlap, regardless of the slit separation of the grating.

3. A patient can't see objects closer than 40.0 cm and wishes to clearly see objects that are 20.0 cm from her eye. (a) Is the patient nearsighted or farsighted? (clicker question) (b) If the person's vision is to be corrected by glasses worn 2.0 cm from the eye, what object distance should be used in the lens equation? (clicker question) (c) What image distance should be used in the lens equation? (clicker question)
(d) Is the image distance positive or negative? (clicker question) (e) Calculate the required focal length and refractive power of the eyeglass lens.

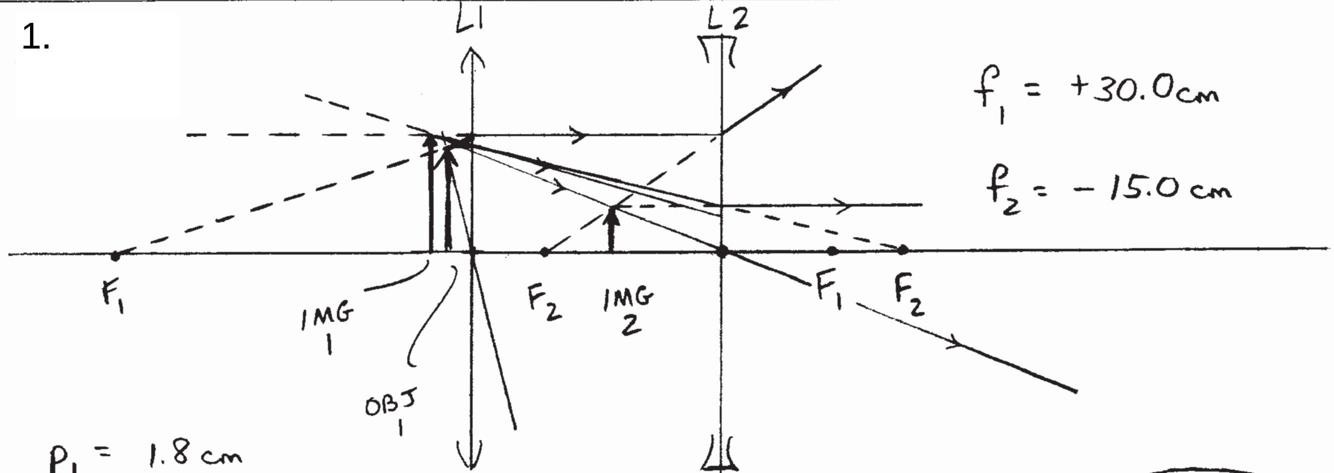
U of S Engineering

CLASS

PROBLEMS

NAME | DATE

1.



$f_1 = +30.0\text{cm}$

$f_2 = -15.0\text{ cm}$

$p_1 = 1.8\text{ cm}$

$h = 2.0\text{ mm}$

$s = 21.0\text{cm}$

(a) $q_1 = \left(\frac{1}{f_1} - \frac{1}{p_1}\right)^{-1} = \left(\frac{1}{+30.0\text{cm}} - \frac{1}{1.8\text{cm}}\right)^{-1} = -1.915\text{ cm} = -1.9\text{cm}$

$p_2 = s - q_1 = 21.0\text{ cm} - (-1.915\text{ cm}) = +22.91\text{ cm}$

$q_2 = \left(\frac{1}{f_2} - \frac{1}{p_2}\right)^{-1} = \left(\frac{1}{-15.0\text{cm}} - \frac{1}{22.91\text{cm}}\right)^{-1} = -9.066\text{ cm} = -9.1\text{cm}$

(b) $m_{tot} = m_1 \cdot m_2$

$m_{tot} = \left(-\frac{q_1}{p_1}\right)\left(-\frac{q_2}{p_2}\right) = \left(-\frac{(-1.915\text{cm})}{1.8\text{cm}}\right)\left(-\frac{(-9.1\text{cm})}{22.91\text{cm}}\right)$

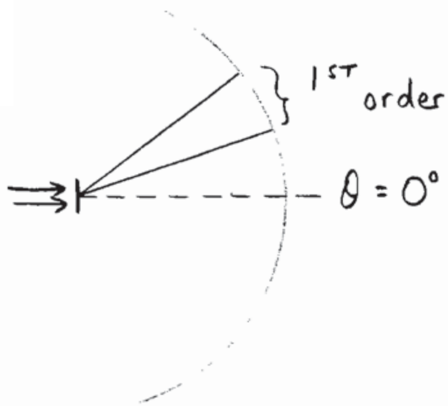
$m_{tot} = 0.42$

(c) $h' = m_{tot} \cdot h = (0.421)(2.0\text{mm}) = 0.84\text{mm}$

PROBLEMS | CLASS

NAME | DATE

2.



Maxima occur at angles satisfying $m\lambda = d \sin\theta$

The larger the wavelength, the larger the angle for a particular order.

For $\lambda = 400\,nm$ to $700\,nm$, 2^{ND} order "finishes" at

$\theta_{2R} = \text{invsin}\left(\frac{2(700\,nm)}{d}\right)$ where d is the slit spacing

$$\theta_{2R} = \text{invsin}\left(\frac{1400\,nm}{d}\right)$$

3^{rd} order <u>begins</u> at $\theta_{3V} = \text{invsin}\left(\frac{3(400\,nm)}{d}\right)$

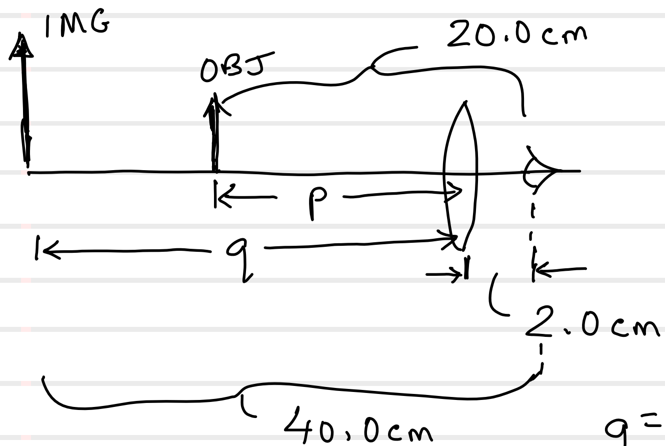
$$\theta_{3V} = \text{invsin}\left(\frac{1200\,nm}{d}\right)$$

Since $\theta_{3V} < \theta_{2R}$, there is some overlap

b/w 2^{ND} and 3^{rd} order regardless of the value of d (as long as $d > 1200\,nm$).

Physics 117.3 Tutorial #5 – Question 3

3. A patient can't see objects closer than 40.0 cm and wishes to clearly see objects that are 20.0 cm from her eye. (a) Is the patient nearsighted or farsighted? (clicker question) (b) If the person's vision is to be corrected by glasses worn 2.0 cm from the eye, what object distance should be used in the lens equation? (clicker question) (c) What image distance should be used in the lens equation? (clicker question) (d) Is the image distance positive or negative? (clicker question) (e) Calculate the required focal length and refractive power of the eyeglass lens.



Person can't see near objects, ∴ farsighted.

$p = 20.0\text{ cm} - 2.0\text{ cm}$

$p = 18.0\text{ cm}$

$q = -(40.0\text{ cm} - 2.0\text{ cm}) = -38.0\text{ cm}$

virtual image

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q} = \frac{1}{0.18\text{ m}} + \frac{1}{-0.38\text{ m}} = +2.92\text{ diopters}$$

$$f\,(\text{m}) = \frac{1}{2.92} = +0.342\text{ m} = +34.2\text{ cm}$$