Name ______________________________

Apr. 26, 2007

Phys 2010, NSCC
Exam #3 — Spring 2007

1.	____________	(14)
2.	____________	(9)
3.	____________	(15)
4.	____________	(16)
5.	____________	(12)
6.	____________	(7)
7.	____________	(11)
8.	____________	(6)
MC	____________	(10)
Total	____________	(100)

Multiple Choice

Choose the best answer from among the four! (2) each.

1. The mass density of aluminum is closest to

a) $0.270\,\frac{\text{kg}}{\text{m}^3}$

b) $2.70\,\frac{\text{kg}}{\text{m}^3}$

$\boxed{\textbf{c)}}$ $2700\,\frac{\text{kg}}{\text{m}^3}$

d) $2.7 \times 10^5\,\frac{\text{kg}}{\text{m}^3}$

2. If the pressure of a fluid is 2.0×10^5 Pa, what force does it exert on a square region of dimensions 10 cm $\times$ 10 cm?

$\boxed{\textbf{a)}}$ 2×10^3 N

b) 2×10^4 N

c) 2×10^6 N

d) 2×10^9 N

3. The speed of sound has a small (but non-negligible) dependence on

$\boxed{\textbf{a)}}$ The temperature of the air.

b) The frequency of the sound wave.

c) The amplitude of the sound wave.

d) None of the above.

4. If the intensity of a sound wave is $1.0 \times 10^{-3} \, \frac{\mathrm{W}}{\mathrm{m}^2}$ then its intensity level is

a) 80 dB

$\boxed{\textbf{b)}}$ 90 dB

c) 100 dB

d) 110 dB

5. For a tube which is open at both ends resonating in the fundamental (lowest frequency sound wave) mode, the length of the tube is equal to

a) $\frac{1}{4}$ wavelength.

$\boxed{\textbf{b)}}$ $\frac{1}{2}$ wavelength.

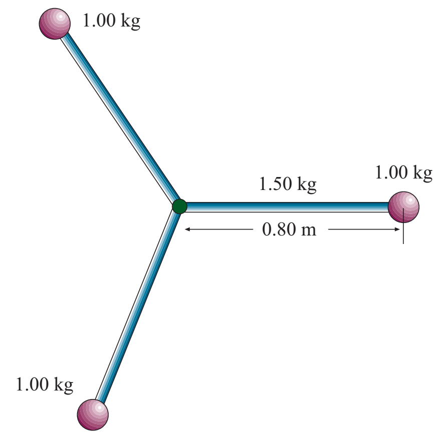
c) 1 wavelength.

d) 2 wavelengths.

Problems

Show your work and include the correct units with your answers!

1. Three uniform bars of mass 1.50 kg and length 0.800 m each are joined together at their ends in a plane to form a rotor; at the end of each bar is a small 1.00 kg mass. (See figure.)



The whole unit is made to rotate around an axis through its center (and perpendicular to the bars).

a) What is the moment of inertia of this object? (5)

Each bar contributes $\frac{1}{3}ML^2$ to the moment of inertia and each mass (being at a distance L from the axis) contributes mL^2, give a total of

$$\begin{aligned} I &= 3(\tfrac{1}{3}ML^2) + 3mL^2 \\ &= (1.50\text{ kg})(0.800\text{ m})^2 + 3(1.00\text{ kg})(0.800\text{ m})^2 = 2.88\,\mathrm{kg\cdot m^2} \end{aligned}$$

b) If a torque of $6.00\,\mathrm{N\cdot m}$ is applied to the object, what is its angular acceleration? (4)

Using $\tau = I\alpha$, get

$$\alpha = \frac{\tau}{I} = \frac{(6.00\,\mathrm{N\cdot m})}{(2.88\,\mathrm{kg\cdot m^2})} = 2.08\tfrac{\mathrm{rad}}{\mathrm{s}^2}$$

c) If the object is initially at rest and this torque is applied, what is its kinetic energy after 5.0 s? (5)

After 5.0 s its angular velocity is

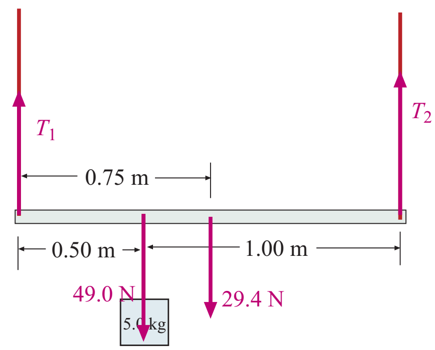
$$\omega = \alpha t = (2.08\tfrac{\mathrm{rad}}{\mathrm{s}^2})(5.0\text{ s}) = 10.4\tfrac{\mathrm{rad}}{\mathrm{s}}$$

and then its kinetic energy is

$$\mathrm{KE} = \tfrac{1}{2}I\omega^2 = \tfrac{1}{2}(2.88\,\mathrm{kg\cdot m^2})(10.4\tfrac{\mathrm{rad}}{\mathrm{s}})^2 = 156\text{ J}$$

2. A uniform bar of length 1.5 m and mass 3.0 kg is supported by vertical cords attached to both ends. There is also a 5.0 kg mass hanging rom the bar, 0.500 m from the left end.

Find the tensions in the two cables. (9)



The *weights* of the bar and hanging mass are, respectively, $W_{\text{bar}} = 29.4$ N and 49.0 N. The forces acting on the bar have been put into the figure.

The total force on the bar is zero. This gives:

$$T_1 + T_2 - 29.4 \text{ N} - 49.0 \text{ N} = 0 \qquad \Longrightarrow \qquad T_1 + T_2 = 78.4 \text{ N}$$

The total torque on the bar is zero. Taking the left end of the bar as the axis, this gives

$$-(0.50 \text{ m})(49.0 \text{ N}) - (0.75 \text{ m})(29.4 \text{ N}) + (1.50 \text{ m})T_2 = 0$$

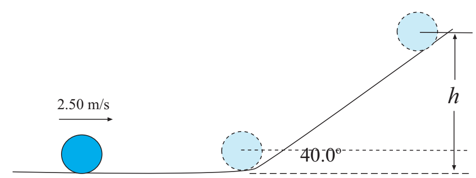
Solve for T_2 and get:

$$T_2 = 31.0 \text{ N}$$

Using this in our force equation gives

$$T_1 = 47.4 \text{ N}$$

3. A uniform solid cylinder of mass 4.0 kg and radius 8.00 cm rolls without slipping on a flat surface. The speed of the cylinder's center is $2.50\frac{\text{m}}{\text{s}}$.



a) What is the angular speed of the cylinder's rotation? (3)

Using $v_c = r\omega$, get:

$$\omega = \frac{v_c}{r} = \frac{(2.50\frac{\text{m}}{\text{s}})}{(0.080 \text{ m})} = 31.2\frac{\text{rad}}{\text{s}}$$

b) What is the (total) kinetic energy of the rolling cylinder? (6)

Using $I_{\text{cyl}} = \frac{1}{2}mr^2$

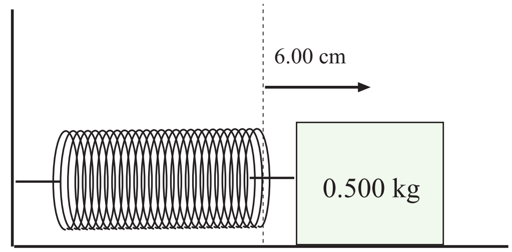
$$\begin{aligned} \text{KE} &= \tfrac{1}{2}mv_c^2 + \tfrac{1}{2}I\omega^2 \\ &= \tfrac{1}{2}(4.0 \text{ kg})(2.5\tfrac{\text{m}}{\text{s}})^2 + \tfrac{1}{2}\tfrac{1}{2}(4.0 \text{ kg})(0.080 \text{ m})^2(31.2\tfrac{\text{rad}}{\text{s}})^2 = 18.8 \text{ J} \end{aligned}$$

c) The cylinder encounters a 40.0° slope and rolls without slipping up the slope. Find the maximum height h attained by the mass. (6)

Between the time the mass is rolling on the flat surface and when it attains maximum height, energy is conserved. In the final position, the cylinder has no kinetic energy; it has potential energy mgh. Then:

$$18.8 \text{ J} = mgh \qquad \Longrightarrow \qquad h = \frac{(18.8 \text{ J})}{(4.0 \text{ kg})(9.80\frac{\text{m}}{\text{s}^2})} = 0.478 \text{ m}$$

4. A 0.500 kg mass oscillates on a horizontal frictionless surface at the end of an ideal spring. To start the motion, the mass is pulled back by 6.0 cm from the no–force position and released. The frequency of the motion is found to be 4.00 Hz.



a) What is the force constant of the spring? (6)

Use

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}} \qquad \Longrightarrow \qquad f^2 = \frac{1}{4\pi^2}\frac{k}{m} \qquad \Longrightarrow \qquad k = 4\pi^2 m f^2$$

Plug in:

$$k = 4\pi^2(0.500\ \mathrm{kg})(4.00\ \mathrm{s}^{-1})^2 = 316\ \tfrac{\mathrm{N}}{\mathrm{m}}$$

b) What is the maximum speed of the mass? (5)

Since

$$\omega = 2\pi f = 2\pi(4.00\ \mathrm{Hz}) = 25.1\tfrac{\mathrm{rad}}{\mathrm{s}}$$

and the amplitude of the motion is $A = 0.060\ \mathrm{m}$, we have

$$v_{\mathrm{max}} = \omega A = (25.1\tfrac{\mathrm{rad}}{\mathrm{s}})(0.060\ \mathrm{m}) = 1.51\tfrac{\mathrm{m}}{\mathrm{s}}$$

c) What is the total mechanical energy of this system? (5)

We can use

$$E = \tfrac{1}{2}kA^2 = \tfrac{1}{2}(316\ \tfrac{\mathrm{N}}{\mathrm{m}})(0.060\ \mathrm{m})^2 = 0.568\ \mathrm{J}$$

5. a) What is the length of simple pendulum such that (on earth) it has a period of oscillation of 6.00 s? (6)

Use

$$T = 2\pi\sqrt{\frac{L}{g}} \qquad \Longrightarrow \qquad T^2 = 4\pi^2\frac{L}{g} \qquad \Longrightarrow \qquad L = \frac{gT^2}{4\pi^2}$$

Plug in:

$$L = \frac{(9.80\frac{\mathrm{m}}{\mathrm{s}^2})(6.00\ \mathrm{s})^2}{4\pi^2} = 8.94\ \mathrm{m}$$

b) If the pendulum in part (a) is used on Mars, where the acceleration of gravity is $3.72\frac{\mathrm{m}}{\mathrm{s}^2}$, what is its period? (4)

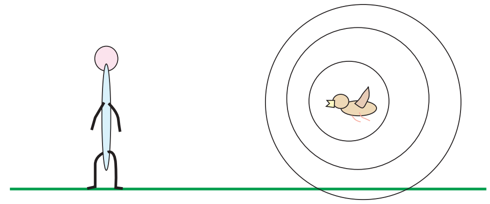
$$T = 2\pi\sqrt{\frac{L}{g_{\mathrm{Mars}}}} = 2\pi\sqrt{\frac{(8.94\ \mathrm{m})}{(3.72\frac{\mathrm{m}}{\mathrm{s}^2})}} = 9.74\ \mathrm{s}$$

c) In deriving the formula for the period of a simple pendulum, an assumption was made regarding the pendulum's motion. What was that assumption? (2)

We assumed that the angle at which the pendulum swings from the vertical would never get very "large". This assumption was necessary in order to get a simple solution for the frequency of the pendulum's motion.

6. A hawk screeches as she flies toward you. You recall that a female hawk screeches at 800 Hz but you hear her screech at 900 Hz.

How fast is the hawk approaching you? (7)



Here we have $f_s = 800$ Hz and $f_o = 900$ Hz; use $v = 343\frac{\mathrm{m}}{\mathrm{s}}$ for the speed of sound. Also, the observer is stationary, $v_o = 0$. Choosing the correct sign in the Doppler formula (bird is flying toward you) we want to solve:

$$f_0 = f_s\left(\frac{1}{1-\frac{v_s}{v}}\right) \qquad \Longrightarrow \qquad (900\ \mathrm{Hz}) = (800\ \mathrm{Hz})\left(\frac{1}{1-\frac{v_s}{v}}\right)$$

Do algebra to find v_s:

$$1 - \frac{v_s}{v} = \frac{800}{900} = 0.889 \qquad \Longrightarrow \qquad \frac{v_s}{v} = 1 - 0.889 = 0.111$$

Finally,

$$v_s = (0.111)v = (0.111)(343\tfrac{\mathrm{m}}{\mathrm{s}}) = 38.1\tfrac{\mathrm{m}}{\mathrm{s}}$$

7. A stretched string of length 2.00 m is under a tension of 60.0 N and has mass density 5.00×10^{-3} kg/m. The string is caused to vibrate in the stable pattern shown at the right

a) What is the wavelength of the wave? (3)

With each segment being half a wavelength, and there being 5 segments, we have

$$L = (2.00\ \mathrm{m}) = 5\frac{\lambda}{2} \qquad \Longrightarrow \qquad \lambda = \frac{2}{5}(2.00\ \mathrm{m}) = 0.80\ \mathrm{m}$$

b) What is the speed of waves on the string? (5)

$$v = \sqrt{\frac{F}{\mu}} = \sqrt{\frac{(60.0\ \mathrm{N})}{(5.00 \times 10^{-3}\ \mathrm{kg/m})}} = 110\tfrac{\mathrm{m}}{\mathrm{s}}$$

c) What is the frequency of oscillation of the wave? (3)

$$f = \frac{v}{\lambda} = \frac{(110\frac{\mathrm{m}}{\mathrm{s}})}{(0.80\ \mathrm{m})} = 137\ \mathrm{Hz}$$

8. When two pure tones of frequencies 440 Hz and 442 Hz are played together, what kind of sound do you hear? (6)

You hear a tone whose basic frequency isclose to 440 Hz but whose loudness varies with a frequency equal to the "beat" frequency which here is

$$f_{\text{beat}} = |f_1 - f_2| = 2\ \text{Hz}$$

You must show all your work and include the right units with your answers!

$$A_x = A\cos\theta \qquad A_y = A\sin\theta \qquad A = \sqrt{A_x^2 + A_y^2} \qquad \tan\theta = A_y/A_x$$

$$v_x = v_{0x} + a_x t \qquad x = v_{0x}t + \tfrac{1}{2}a_x t^2 \qquad v_x^2 = v_{0x}^2 + 2a_x x \qquad x = \tfrac{1}{2}(v_{0x} + v_x)t$$

$$g = 9.80\tfrac{\text{m}}{\text{s}^2} \qquad R = \frac{2v_0^2\sin\theta\cos\theta}{g} \qquad \mathbf{F}_{\text{net}} = m\mathbf{a} \qquad \text{Weight} = mg$$

$$F = G\frac{m_1 m_2}{r^2} \qquad G = 6.67\times10^{-11}\tfrac{\text{N}\cdot\text{m}^2}{\text{kg}^2} \qquad f_{\text{s}}^{\text{Max}} = \mu_s F_N \qquad f_{\text{k}} = \mu_{\text{k}} F_N$$

$$v = \frac{2\pi R}{T} \qquad a_c = \frac{v^2}{r} \qquad F_c = \frac{mv^2}{r} \qquad W = Fs\cos\theta$$

$$\text{PE}_{\text{grav}} = mgh \qquad \text{KE} = \tfrac{1}{2}mv^2 \qquad E = \text{PE} + \text{KE} \qquad \Delta E = W_{\text{nc}} \qquad P = \frac{W}{t}$$

$$\mathbf{p} = m\mathbf{v} \qquad \text{For isolated system} \quad \mathbf{p}_{\text{Tot}} \quad \text{is conserved} \qquad 1\ \text{rev} = 360\ \text{deg} = 2\pi\ \text{rad}$$

$$\omega = \omega_0 + \alpha t \qquad \theta = \omega_0 t + \tfrac{1}{2}\alpha t^2 \qquad \omega^2 = \omega_0^2 + 2\alpha\theta \qquad \theta = \tfrac{1}{2}(\omega_0 + \omega)t \qquad s = r\theta \qquad v_T = r\omega$$

$$a_T = r\alpha \qquad a_c = r\omega^2 \qquad \tau = Fr\sin\phi \qquad \tau = I\alpha \qquad \text{KE}_{\text{rot}} = \tfrac{1}{2}I\omega^2$$

$$I_{\text{disk}} = \tfrac{1}{2}MR^2 \qquad I_{\text{sph}} = \tfrac{2}{5}MR^2 \qquad I_{\text{rod, end}} = \tfrac{1}{3}ML^2 \qquad I_{\text{rod, mid}} = \tfrac{1}{12}ML^2$$

$$v_c = r\omega \qquad a_c = r\alpha \qquad \text{KE}_{\text{roll}} = \tfrac{1}{2}mv^2 + \tfrac{1}{2}I\omega^2$$

$$L = I\omega \qquad \text{For system with no ext torques} \quad L_{\text{Tot}} \quad \text{is conserved}$$

$$F_{\text{spr},x} = -kx \qquad \text{PE}_{\text{spr}} = \tfrac{1}{2}kx^2 \qquad T = \frac{1}{f} \qquad \omega = 2\pi f$$

$$\omega = \sqrt{\frac{k}{m}} \qquad v_{\text{max}} = \omega A \qquad a_{\text{max}} = \omega^2 A \qquad T = 2\pi\sqrt{\frac{L}{g}} \qquad \omega = \sqrt{\frac{I}{mgL}}$$

$$\lambda f = v \qquad v = \sqrt{\frac{F}{\mu}} \qquad \mu = \frac{M}{L} \qquad I = \frac{P}{4\pi r^2} \qquad \beta = (10\ \text{dB})\log_{10}\left(\frac{I}{I_0}\right) \qquad I_0 = 10^{-12}\ \tfrac{\text{W}}{\text{m}^2}$$

$$f_{\text{beat}} = |f_1 - f_2| \qquad f_o = f_s\left(\frac{1 \pm \frac{v_o}{v}}{1 \mp \frac{v_s}{v}}\right) \qquad \text{with:} \begin{pmatrix}\text{Toward}\\ \text{Away}\end{pmatrix}$$

$$\text{Use} \qquad 343\tfrac{\text{m}}{\text{s}} \quad \text{for speed of sound} \qquad \rho = \frac{m}{V} \qquad P = \frac{F}{A}$$