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General Physics I, Midterm 2
PHYS10400, Class year 100
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SN:__________________, Name:_______________

Solution:

1. The speakers broadcast equally in all directions, so the intensity of sound is inversely proportional to the square of the distance from its source.

(a) $r_{AC} = \sqrt{3.00^2 + 4.00^2}\,\text{m} = 5.00\ \text{m}$

$$I = \frac{P}{4\pi r^2} = \frac{1.00\times10^{-3}\,\text{W}}{4\pi\left(5.00\ \text{m}\right)^2} = 3.18\times10^{-6}\ \text{W/m}^2$$

$$\beta = \left(10\ \text{dB}\right)\log\left(\frac{3.18\times10^{-6}\ \text{W/m}^2}{10^{-12}\ \text{W/m}^2}\right)$$

$$\beta = \left(10\ \text{dB}\right)6.50 = 65.0\ \text{dB}$$

(b) $r_{BC} = 4.47\ \text{m}$

$$I = \frac{1.50\times10^{-3}\ \text{W}}{4\pi\left(4.47\ \text{m}\right)^2} = 5.97\times10^{-6}\ \text{W/m}^2 \quad \beta = \left(10\ \text{dB}\right)\log\left(\frac{5.97\times10^{-6}}{10^{-12}}\right)$$

$$\beta = 67.8\ \text{dB}$$

(c) $I = 3.18\mu\text{W/m}^2 + 5.97\ \mu\text{W/m}^2$

$$\beta = \left(10\ \text{dB}\right)\log\left(\frac{9.15\times10^{-6}}{10^{-12}}\right) = 69.6\ \text{dB}$$

2.

(a) $\sum \vec{F} = -2T \sin\theta\, \hat{j}$ where $\theta = \tan^{-1}\left(\frac{y}{L}\right)$

Therefore, for a small displacement

$\sin\theta \approx \tan\theta =$ and $\sum \vec{F} = \frac{-2Ty}{L}\hat{j}$

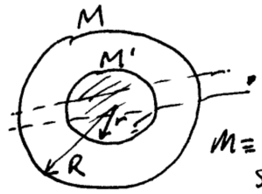
(b) The total force exerted on the ball is opposite in direction and proportional to its displacement from equilibrium, so the ball moves with simple harmonic motion. For a spring system,

$$\sum \vec{F} = -k\vec{x} \quad \text{becomes here} \quad \sum \vec{F} = -\frac{2T}{L}\vec{y}$$

Therefore, the effective spring constant is $\frac{2T}{L}$ and $\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{2T}{mL}}$.

3.

(a) the force of the stone inside the tunnel is



m ≡ the mass of the stone

$$F = -\frac{GM'm}{r^2} = -\frac{Gm}{r^2}\frac{4}{3}\pi\rho r^3$$

$$= -\frac{4}{3}\pi\rho Gmr$$

$$= -kr \quad , \quad k \equiv \frac{4}{3}\pi\rho Gm$$

→ therefore the stone acts like a SHO with force constant k as defined

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

$$= \frac{2\pi}{\sqrt{\frac{4}{3}\pi\rho G}}$$

But at the surface. the weight of the mass is

$$W = mg = \frac{GMm}{R^2} = \frac{4}{3}\pi\rho GmR$$

$$\therefore \frac{g}{R} = \frac{4}{3}\pi\rho G$$

$$\Rightarrow T = 2\pi\sqrt{\frac{R}{g}} = 2\pi\sqrt{\frac{6370\times10^3\,m}{9.8\times m.s^{-2}}} = 84.8\ min$$

(b) The period of an earth satellite in a circular orbit is
Use Kepler's 3rd law, $T^2 = \left(\frac{4\pi^2}{GM}\right)a^3$ — (13.8) in text book.

Also $g = \frac{GM}{R^2}$

$$\therefore T^2 = \frac{4\pi^2 d^3}{R^2 g} \quad , \quad d = R + h.$$

R ≡ earth radius
h ≡ the height of satellite

(c) in the first approximation $R \approx d$ then

$$T^2 = 4\pi^2\frac{R}{g} \Rightarrow T = 2\pi\sqrt{\frac{R}{g}}$$

That means if we do not consider the height of the Satellite. it will have the same period as that of the stone in (a)

4.

(a) $I_{hoop} = \frac{1}{2}mR^2$ for hoop rotates about its diameter

$I_{\substack{Rod\\com}} = \frac{1}{12}mL^2$. for rod rotates about its center of mass

In this case, Use parallel theorem.

$$I_{rod} = I_{rod.center} + m h_{com}^2$$

$$= \frac{1}{12}ML^2 + m\left(R + \frac{L}{2}\right)^2 = 4.33\, mR^2$$

$$\therefore I = I_{hoop} + I_{rod} = \frac{1}{2}mR^2 + 4.33mR^2 = 4.8\, mR^2$$

(b) Use the Conservation of energy $\Delta E = 0$

$$\therefore \Delta E_K + \Delta E_U = 0$$

$\Delta E_K = K_f - K_i = \frac{1}{2}I\omega^2 - 0 = \frac{1}{2}I\omega^2$

$\Delta E_U = (2m)g\,\Delta y$. $\Delta y \equiv$ vertical displacement of its center of mass

initially. y_{cm} at ~~$y = R + \frac{L}{2}$~~

$$y_{cm} = \frac{m(0) + m(R + \frac{L}{2})}{2m} = R$$

final y is the same distance R from the rotational axis

$$\therefore \Delta y = -2R$$

Thus $\frac{1}{2}I\omega^2 + 2mg\,\Delta y = 0$

plug in all numbers $\omega = \sqrt{\frac{8g}{4.83R}} = \sqrt{\frac{8 \times 9.8}{4.83 \times 0.15}}$

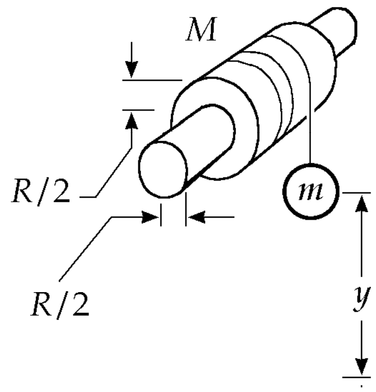
$= 10$ rad/sec

5.

τ_f will oppose the torque due to the hanging object:

$\sum \tau = I\alpha = TR - \tau_f$:

$\tau_f = TR - I\alpha$ (1)



Now find T, I and α in given or known terms and substitute into equation (1). $\sum F_y = T - mg = -ma$: (2)

also $\Delta y = v_i t + \frac{at^2}{2}$, $a = \frac{2y}{t^2}$ (3)

and $\alpha = \frac{a}{R} = \frac{2y}{Rt^2}$: (4)

$I = \frac{1}{2}M\left[R^2 + \left(\frac{R}{2}\right)^2\right] = \frac{5}{8}MR^2$ (5)

Substituting (2), (3), (4), and (5) into (1), we find $\tau_f = m\left(g - \frac{2y}{t^2}\right)R - \frac{5}{8}\frac{MR^2(2y)}{Rt^2} = \boxed{R\left[m\left(g - \frac{2y}{t^2}\right) - \frac{5}{4}\frac{My}{t^2}\right]}$