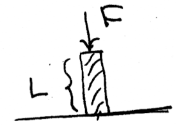
Problems of chapter 10

(1) $F = 5.8 \times 10^{4}\ N$, $L = 2.5\ m$, $A = 7.5 \times 10^{-3}\ m^2$

$\Delta L = ?$ (vertical compression)



$$\frac{F}{A} = Y \frac{\Delta L}{L}$$

$$\frac{5.8 \times 10^{4}}{7.5 \times 10^{-3}} = \underbrace{(200 \times 10^{9}\ Pa)}_{\text{from the table in the book}} \frac{\Delta L}{2.5} \rightarrow \boxed{\Delta L = 0.097\ mm}$$

(11) Set the stress equal to the tensile strength of the hair:

$$\frac{F}{A} = \frac{F}{\pi r^2} \qquad r = \text{radius} \qquad \times 10^{-4}$$

$$2 \times 10^{8}\ Pa = \frac{1.2\ N}{\pi (r)^2} \Rightarrow \boxed{r = 4.4 \times 10^{-5}\ m}$$

Diameter $= 2r = 8.8 \times 10^{-5}\ m$

(27)

The weight of the 24-kg child compresses the spring by 28 cm. Thus:

$$mg = kx \rightarrow k = \frac{mg}{x} = \frac{(24)(9.8)}{0.28}$$

$$\boxed{k = 840 \text{ N/m}}$$

Since $f_{child} = 0.88 \text{ Hz} \Rightarrow f_{child} = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$

$m \rightarrow m_{child} + m_{horse}$

$$0.88 = \frac{1}{2\pi}\sqrt{\frac{840}{m}} \rightarrow m = 27.5 \text{ kg}$$

$$m_{horse} = 27.5 - 24 = 3.5 \text{ kg}$$

with the horse alone oscillating

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m_{horse}}} = \frac{1}{2\pi}\sqrt{\frac{840}{3.5}}$$

$$\boxed{f = 2.5 \text{ Hz}}$$

(37) a) $v_m = A\omega$, with A = Amplitude and $\omega = 2\pi f$

So for a fixed amplitude A, v_m occurs for a high frequency Sound wave.

$a_m = \omega^2 A \rightarrow$ (same argument as above)

b) $A = 1.0 \times 10^{-8}\ m$, $f = 20\ HZ \rightarrow$

$$v_m = A\omega = A\,2\pi f = \dots = 1.3 \times 10^{-6}\ m/s$$

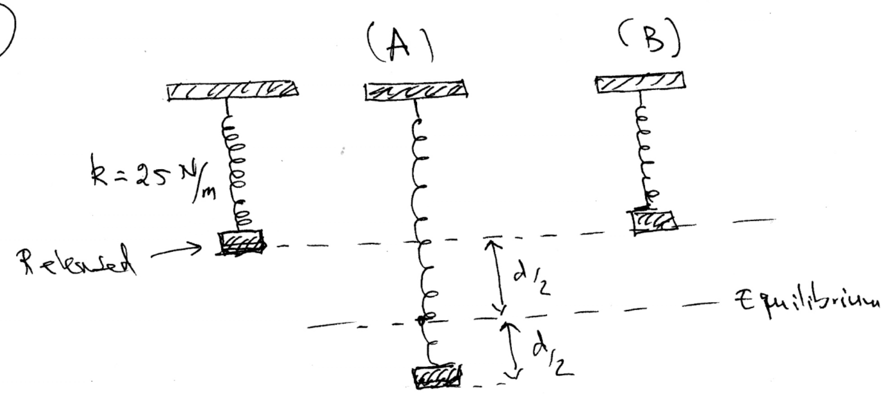
$$a_m = A\omega^2 = A(2\pi f)^2 = \dots = 1.6 \times 10^{-4}\ m/s^2$$

c) If $f = 20\ kHZ = 20{,}000\ HZ$

$$\rightarrow v_m = 0.0013\ m/s = 1.3\ mm/s$$

$$a_m = 160\ m/s^2 \ !$$

42



At any moment $\sum \vec{F} = m\vec{a}$

m = mass of oscillating body

$$\vec{F}_{gravity} + \vec{F}_{spring} = m\vec{a}$$

a)

in (A): $-mg + kd = ma$

At equilibrium $-mg + \frac{kd}{2} = m\cancel{a}_0$

$$\Rightarrow kd = 2mg$$

$$-\cancel{m}g + 2\cancel{m}g = \cancel{m}a$$

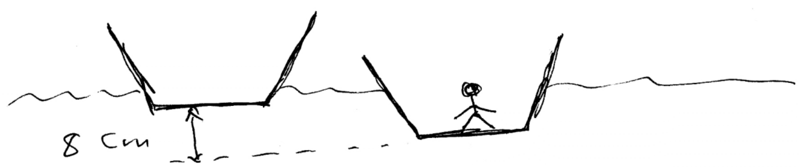
$$\boxed{a = g}$$

b)

$kd = 2mg \rightarrow d = 2\frac{mg}{k} = \frac{2(1)(9.8)}{25} = 0.78\ m$

$= 78cm$

(45) $m_{boat} = 47$ kg $m_{person} = 92$ kg



The boat plays the role of "spring" and the man is the hanging mass.

At equilibrium $m_{person}\, g = kA \rightarrow A = \frac{8}{2} = 4$ cm

$$k = \frac{(92)(9.8)}{0.04} = 22540 \text{ N/m}$$

$$T = 2\pi\sqrt{\frac{m}{k}} \rightarrow$$ This "m" is the total mass

$$T = 2\pi\sqrt{\frac{47+92}{22540}} = \boxed{0.7 \text{ s}}$$

(47)

$Y(t) = 8 \sin 1.57 t$

Compare this with $Y(t) = Y_m \sin \omega t$

$Y_m = 8 \text{ cm}$ $\qquad$ $\omega = 1.57 \text{ rad/s}$

Thus $\omega = 2\pi f \rightarrow f = \dfrac{\omega}{2\pi} = \dfrac{1.57}{2\pi} = \boxed{\dfrac{1}{4} \text{ Hz}}$

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(57) $T = 1.5 \text{ s}$

$m = 0.5 \text{ kg}$

Since amplitudes are small, we can use

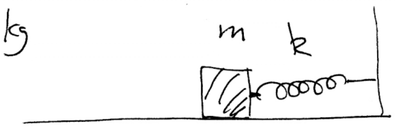
$$T = 2\pi \sqrt{\frac{l}{g}}$$

Which is independent of "amplitude" and "mass."

Thus $\boxed{T = 1.5 \text{ s}}$

89

$k = 9.82$ N/m $\quad m = 1.24$ kg



At $x = 0.345$ m, $V = 0.543$ $\rightarrow E = \frac{1}{2}mv^2 + \frac{1}{2}kx^2$

a) $= \dots = 0.77\,J$

At max stretch $E = \frac{1}{2}kA^2 = 0.77\,J$

$\Rightarrow A = \sqrt{\frac{2(0.77)}{9.82}} = \boxed{0.395\,m}$

b) $v_m = \omega A = \sqrt{\frac{k}{m}}A = \sqrt{\frac{9.82}{1.24}}(0.395) = 1.11$ m/s

You may also use energy method

$E = \frac{1}{2}mV_m^2$

$\downarrow$

$0.77 = \frac{1}{2}(1.2)V_m^2 \rightarrow V_m = 1.11$ m/s

c) Again using energy method

$E = \frac{1}{2}mv^2 + \frac{1}{2}kx^2$

$\downarrow$

$0.77 = \frac{1}{2}(1.24)v^2 + \frac{1}{2}(9.82)(0.2)^2 \rightarrow$

$v = 0.96$ m/s