(1) Maximum pressure that is survivable : 1000 times atmospheric pressure.

What is the maximum depth such organism can withstand in the sea?

$$P_{max} = \boxed{1000} \text{ atm}$$

$$1 \text{ atm} = 101.3 \text{ kPa} \quad \text{(from book page 303)}$$

$$\Rightarrow P_{max} = \boxed{101300} \text{ kPa}$$

$$= \boxed{1.013 \cdot 10^8} \text{ Pa}$$

We know that pressure in the ocean depends on depth according to $p = \rho g h$, where h is the depth and ρ is density of water

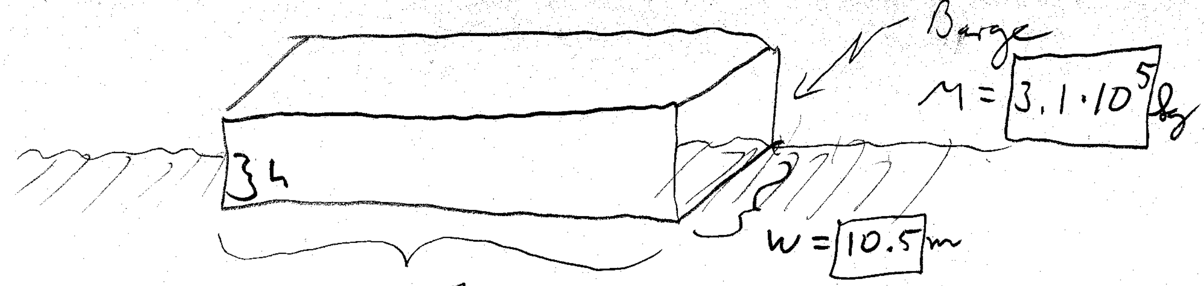
$$\Rightarrow P_{max} = \rho g h \quad , \rho = 1027 \text{ kg/m}^3$$

$$\Rightarrow h = \frac{P_{max}}{\rho g}$$

$$\Rightarrow h = \frac{\boxed{1.013 \cdot 10^8} \text{ Pa}}{1027 \frac{\text{kg}}{\text{m}^3} \cdot 9.8 \frac{\text{m}}{\text{s}^2}} \quad \left(1 \text{ Pa} = \frac{N}{m^2} = \frac{kg\, m}{s^2\, m^2} \right)$$

$$h = \boxed{10065} \frac{\cancel{kg}\, \cancel{m}/s^2 m^2}{\cancel{kg}\, \cancel{m}/m^3 s^2} \simeq \boxed{10.1 \cdot 10^3} \text{ m} = \boxed{10.1} \text{ km}$$

(2)



$l \cdot w = A$ = Area of bottom

The weight of the barge must equal the weight of the displaced water!

We can see this from ($\rho = \rho_{water}$), (h = depth), (A = Area of barge bottom)

$$\rho g h = \text{Pressure} = \frac{F_{\text{on B by Water}}}{A} \leftarrow \text{this must cancel gravity } (mg)$$

multiply by A: ($h \cdot A$ = Volume of displaced water)

$$\rho g V_{\text{displaced Water}} = F_{\text{on barge by Water}} \overset{!}{=} M g \quad \leftarrow \text{for it to swim!}$$

So:

weight of displaced water = weight of barge

Volume of displaced water!

$$W_w = W_B \qquad \left(\text{but } m_{water} = \rho \cdot V_{water}\text{, so } \rho_{water} g V = M_{water} g = \underline{\text{weight}}\right)$$

$$\rho_{water} g V = M g$$

$$\Rightarrow \quad V = \frac{M}{\rho} \quad (\text{, but } V = l \cdot w \cdot h)$$

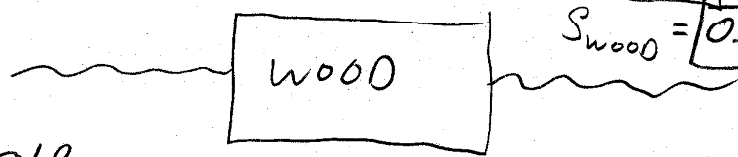
$$\Rightarrow \quad h = \frac{M}{l \cdot w \cdot \rho} = \frac{M}{A \cdot \rho} = \frac{\boxed{3.1 \cdot 10^5}\,\text{kg}}{\boxed{20.2\,\text{m}}\,\boxed{10.5\,\text{m}} \cdot \underbrace{10^3 \frac{\text{kg}}{\text{m}^3}}_{\rho_{water}}}$$

$\Rightarrow$ $h = \boxed{1.5}\ m$

(3)

$\boxed{83.9\%}$ submerged!

$\rho_{WOOD} = \boxed{0.65}\ g/cm^3$



oil

$\boxed{\rho_{oil} = ?}$

The ratio of densities is equal to the ratio of Volumes:

$83.9\% = 0.839$!

$$\frac{\rho_{wood}}{\rho_{oil}} = \frac{V_{submerged}}{V_{total}} = \boxed{0.839}$$

$$\Rightarrow \rho_{wood} = 0.839\, \rho_{oil}$$

$$\Rightarrow \rho_{oil} = \frac{1}{\boxed{0.839}}\rho_{wood} = \frac{1}{\boxed{0.839}}\boxed{0.65}\ g/cm^3$$

$$\Rightarrow \rho_{oil} = \boxed{0.775}\ g/cm^3$$

(4) Airplane, level path:

$V_2 = \boxed{80.8}\ m/s$

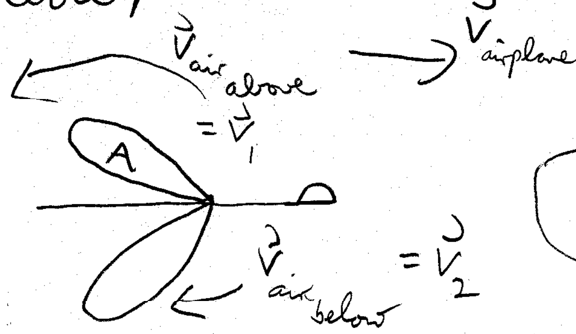
$A = \boxed{190}\ m^2$

$P_2 - P_1 = \Delta P = \boxed{540}\ Pa$

$P_{above} = P_1$

$P_1 < P_2$ ☐

$P_{below} = P_2$



$V_2 < V_1$ ☐

it flies because the pressure above the wings is <u>less</u> than the pressure below the wings, which results in an upward net force on the wings, that cancels the downward gravity force!

For the pressure above the wings to be <u>less</u> than below the air must flow by <u>faster</u> above the wings than below the wings!

b) $V_1 = ?$, use Bernoulli's law: (2: below, 1: above)

$$\frac{1}{2}\rho v_1^2 - \frac{1}{2}\rho v_2^2 = \Delta P$$

where Δp = pressure difference $= P_2 - P_1 = \boxed{540}\ Pa$

and V_2 given as $v_2 = \boxed{80.8}\ m/s$

and $\rho = \rho_{air} = 1.29\ kg/m^3$ (from book page 307)
(up there it is 0°C!)

$$\Rightarrow\ V_1^2 = \left(\boxed{540}\ Pa + \frac{1}{2}(1.29\ kg/m^3)\boxed{80.8}\ m/s\right) \cdot 2\,\frac{1}{1.29\ kg/m^3}$$

$$\Rightarrow V_1^2 = 7365.85 \ m^2/s^2$$

$$\Rightarrow V_1 = 85.8 \ m/s$$

a) $W_{plane} = ?$

Pressure times area is force, the force due to ΔP must cancel gravity.

Force on wings due to ΔP:

$$\Delta P = \boxed{540}\,Pa = \frac{F}{A} \Rightarrow F = \boxed{540}\,Pa \cdot A$$

$$\Rightarrow F = \boxed{540}\,Pa \cdot 2 \cdot \boxed{190}\,m^2$$

$$\Rightarrow F = 2.052 \cdot 10^5 \, N$$

This is the force due to ΔP and this must be equal to the force due to gravity, which is the weight of the plane.

1

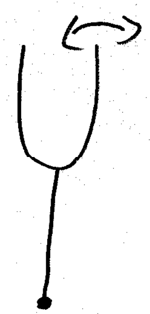
$$\Rightarrow W_{plane} = 2.052 \cdot 10^5 \, N$$

Mistake on Webassign: They used only one wing and thus the answer they want is $\boxed{1.03 \cdot 10^5}\,N$

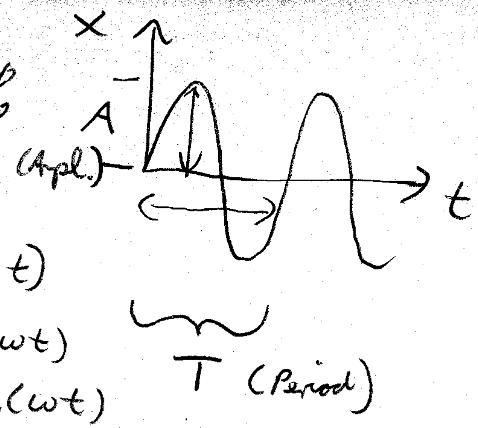
4

6/9

(5)



SHM:

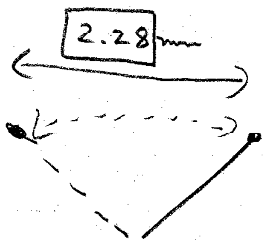


$x = A\sin(\omega t)$

$v = A\omega\cos(\omega t)$

$a = -A\omega^2\sin(\omega t)$

Prong moves $\boxed{2.28}$ mm between far left and far right positions:



$\Rightarrow$ Amplitude of SHM is one half of that (Amplitude is measured from middle to extreme, not from extreme to extreme) $A = \boxed{1.14\text{ mm}}$ //

frequency of prong $f = \boxed{440.2}$ Hz

$\rightarrow$ find V_{max} and a_{max}

$\omega = 2\pi f$

$\Rightarrow$ from book $V_{max} = \text{Amplitude} \cdot \omega$

$= \boxed{1.14}\text{ mm} \cdot 2\pi \cdot \boxed{440.2}\text{ Hz}$

$V_{max} = \boxed{3153}\text{ mm/s} = \boxed{3.15}\text{ m/s}$ //

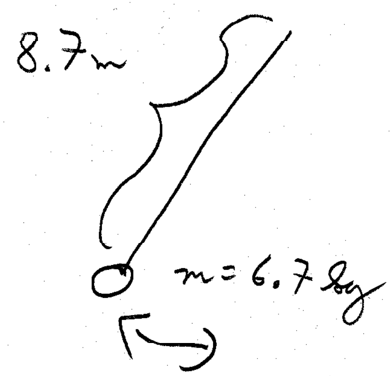
from book $a_{max} = \text{Amplitude} \cdot \omega^2$

$$= \boxed{1.14}\,\text{mm} \cdot \left(2\pi \boxed{440.2}\,\text{Hz}\right)^2$$

$$= 8720967.43 \ \text{mm/s}^2$$

$$a_{max} \simeq 8720 \ \text{m/s}^2$$

6



note: indep. of mass!

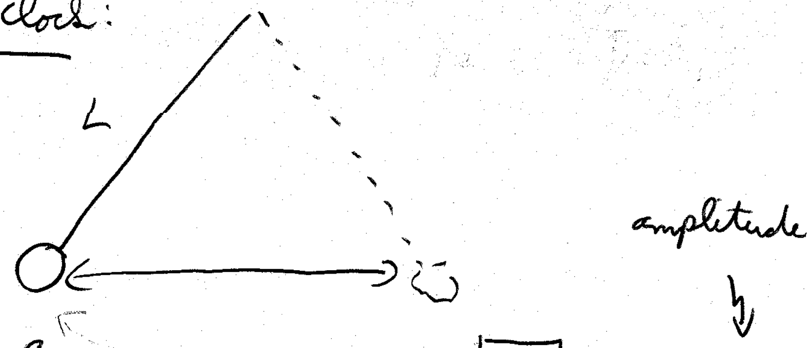
$T = ?$, pendulum, from lecture $\omega_{pend.} = \sqrt{\frac{g}{L}}$

but $\omega = 2\pi f = \frac{2\pi}{T}$

$$\Rightarrow T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{L}{g}}$$

$$\Rightarrow T = 2\pi\sqrt{\frac{\boxed{8.7}\,\text{m}}{9.8\ \text{m/s}^2}} = \boxed{5.92}\,\text{s}$$

7) Grandfather clock:



from one side to other: $\boxed{24}$ mm $\Rightarrow A = \boxed{12}$ mm

$\boxed{1}$ s $\Rightarrow T = \boxed{2}$ s

a) assume SHM, use relation between A and v_{max}:

$$v_{max} = A\omega = A\, 2\pi f = A \cdot 2\pi \frac{1}{T}$$

$$\Rightarrow \quad v_{max} = \boxed{12}\,\text{mm} \cdot 2\pi \cdot \frac{1}{\boxed{2}\,\text{s}} = \boxed{37.7}\,\frac{\text{mm}}{\text{s}} = \boxed{3.8}\,\frac{\text{cm}}{\text{s}}$$

The period is two sec. because in one period, it has to go from left to right AND back!

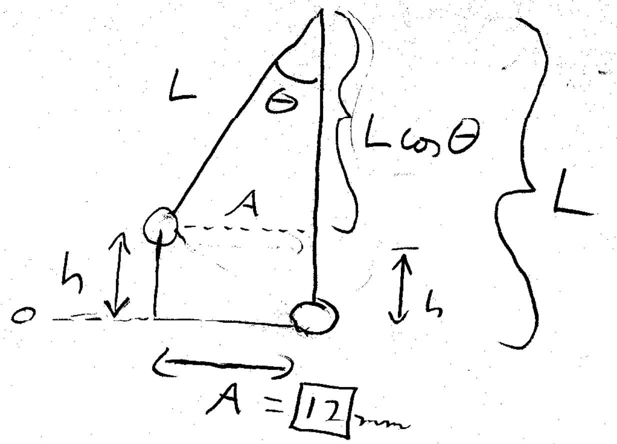
- mistake in my Webassign solution
- they want $\boxed{1.51}$ cm/s as answer, which is obviously wrong!

b) Use energy conservation:

At it's point furthest to the left, it has zero speed and only potential energy ($= mgh$); at it's bottom point, it has MAX speed and only kinetic energy ($= \frac{1}{2}mv^2$)

(Here, I choose my zero-point of potential E. at the bottom)

19/19



From the picture, we see that $L - h = L\cos\theta$

so $h = L(1-\cos\theta)$

- Get L from $T = 2\pi\sqrt{\frac{L}{g}} \Rightarrow L = \frac{T^2}{(2\pi)^2} g = \boxed{0.992948}\,m$

- Get θ from $A = L\sin\theta$, we can only solve this pendulum for small θ; this becomes $(\sin\theta \simeq \theta)$

$$A \simeq L\theta \Rightarrow \theta \simeq \frac{A}{L} = \frac{\boxed{12}\cdot 10^{-3}\,m}{\boxed{0.992948}\,m} = \boxed{1.21\cdot 10^{-2}\,rad}$$

then $h = L(1-\cos\theta) = \boxed{0.992948}\,m\,(1-\cos(\boxed{1.21\cdot 10^{-2}}\,rad))$

$\Rightarrow h = \boxed{7.27\cdot 10^{-5}}\,m$

same as a) !

now use E. conservation

$$mgh = \frac{1}{2} m v_{max}^2 \Rightarrow v_{max} = \sqrt{2gh} = \boxed{0.0377}\,\frac{m}{s} = \boxed{3.8}\,\frac{cm}{s}$$