HW7
Physics I

17.5/20

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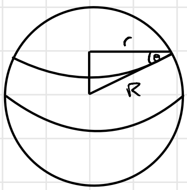
1) $h$ = hight , $\theta$ = latitud , $\vec{\omega}$ Earth's rot



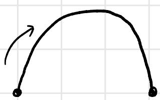

$r = R\cos\theta$

$$\omega = \frac{2\pi}{24h} = \frac{2\pi}{24 \cdot 3600\,s} \Rightarrow \omega = 7.27 \times 10^{-5}\ \frac{1}{s}$$

Then the velocity $v = \omega r = \omega \cdot R\cos\theta$
$= 7.27 \times 10^{-5}\ \frac{1}{s} \cdot 6.371 \times 10^{6} m \cdot \cos\theta$

• $s = v \cdot t$

Further $h = v_0 t - \frac{1}{2} g t^2$ but it is a parabola



$$\Rightarrow h = \frac{1}{2} g t^2 \Rightarrow t = \sqrt{\frac{2h}{g}}$$

Thus the total time is $t_{tot} = 2\sqrt{\frac{2h}{g}}$

then $s = v \cdot t = 7.27 \times 10^{-5}\ \frac{1}{s} \cdot 6.371 \times 10^{6} m \cdot \cos\theta \cdot 2\sqrt{\frac{2h}{g}} = \ldots$

to the west.

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## 2) Floating Iceberg

Find fraction of volume of iceberg below sea level.

Let $m_i$ and $V_i$ be its mass and volume.
Mass density of ice is $M/V = \rho_i = 0.917\ g/cm^3$ ✓

Let $V_w$ be the volume below water = volume of water displaced, its mass : $m_w = \rho_w V_w$ with $\rho_w = 1\ g/cm^3$ (water)

Then the weight of the iceberg is given by

$$W_i = m_i \cdot g \quad , \quad g = 9.81\ \frac{m}{s^2}$$ ✓

And buoyant force equals weight of displaced water, thus

$$W_w = M_w \cdot g$$ ✓

and since it floats

$$W_w = W_i$$
$$\Rightarrow \quad M_w g = M_i g$$
$$V_w \rho_w = V_i \rho_i$$
$$\Rightarrow \quad V_w = \rho_i / \rho_w \cdot V_i$$

$\Rightarrow$ $\frac{V_w}{V_i}$ (fraction of the iceberg underwater) is given by $\rho_i / \rho_w = 0.917 \Rightarrow \approx 91\ \%$ of the iceberg is underwater. ✓

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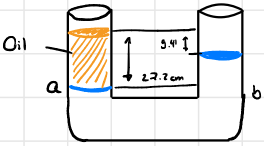
## 3. Water and oil

• Density of oil



$\rho_w = \rho_{oil}$ , Then $\rho_w \cdot h_w \cdot g = \rho_{oil} \cdot h_{oil} \cdot g$

$$\Longrightarrow \rho_{oil} = \frac{\rho_w \cdot h_w}{h_{oil}} = \frac{1000 \frac{kg}{m^3} \cdot \overbrace{0.1779m}^{27.2cm - 9.41cm}}{0.272m} = 654 \frac{kg}{m^3}$$

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## 4. Pipe in Building

pressure = 3.8 atm , speed $0.6 \frac{m}{s}$ , $\text{diameter}_{street}$ 5cm

$\text{diameter}_{top}$ 2.6cm , 18m to top

Flow velocity and gauge pressure on the top floor.

- $P + \rho g h + \frac{1}{2} \rho v^2 = \text{constant}.$
- $I_v = v A = \text{constant}$

$$v_1 A_1 = v_2 A_2$$

$$\Longrightarrow v_2 = \frac{A_1 v_1}{A_2} = \frac{v_1 \cancel{\pi} \cdot r_1^2}{\cancel{\pi} r_2^2} = \frac{0.6 \frac{m}{s} \cdot (0.025m)^2}{(0.013m)^2} = 2.22 \frac{m}{s}$$

$$P_{before} + \underbrace{\rho \cdot g \cdot h}_{0} + \frac{1}{2} \rho v_1^2 = P_{after} + \rho \cdot g \cdot h + \frac{1}{2} \rho v_2^2$$

$$P_{after} = P_{before} + \frac{1}{2} \rho v_1^2 - \rho \cdot g \cdot h - \frac{1}{2} \rho v_2^2$$

$$= P_{before} + \frac{1}{2} \rho (v_1^2 - v_2^2) - \rho \cdot g \cdot h$$

$$= 3.838 \cdot 10^5 \text{ Pa} + \frac{1}{2} \cdot 1000 \frac{kg}{m^3} \left( \left(0.6 \frac{m}{s}\right)^2 - \left(2.22 \frac{m}{s}\right)^2 \right) - 1000 \frac{kg}{m^3} \cdot 9.81 \frac{m}{s^2} \cdot 18m$$

$$= 2.05 \cdot 10^5 \text{ Pa} \qquad (1 \text{ atm} \sim 101'325 \text{ Pa})$$

$$\Longrightarrow 2.02 \text{ atm}$$

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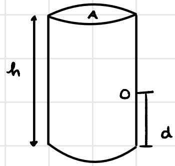
5. Water shooting out of tank

density $\rho$ , Area $A$ , height $h$ , piston mass $m$

$A_s$ area of spout.




level a        level b

$$(p_{atm} + p_{piston}) + \rho \cdot g \cdot h + \frac{1}{2}\rho v_a^2 = p_{atm} + \rho \cdot g \cdot h + \frac{1}{2}\rho v_o^2$$

$$\Rightarrow \quad p_{piston} + \rho \cdot g \cdot h = \frac{1}{2}\rho v_o^2$$

$$\Rightarrow \quad v_o = \sqrt{\frac{2}{\rho}\left(p_{piston} + \rho g h\right)}$$

<u>vertical</u>

$$s = \frac{1}{2} g t^2 \text{ , then } d = \frac{1}{2} g t^2 \Rightarrow t = \sqrt{\frac{2d}{g}}$$

<u>horizontal</u>

$$s = v_o \cdot t = \sqrt{\frac{2}{\rho}\left(p_{piston} + \rho \cdot g \cdot h\right)} \cdot \sqrt{\frac{2d}{g}}$$

$$= \sqrt{\frac{4d}{\rho g}\left(p_{pist.} + \rho \cdot g \cdot h\right)}$$

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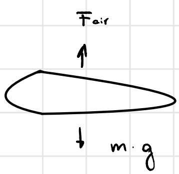
6. Airplane




$$\sum F_y = 0 \Rightarrow F_{air} - mg = 0$$

- $P + \rho \cdot g \cdot h + \frac{1}{2}\rho v^2 = \text{constant}$

Then $P_{low} + \rho \cdot g \cdot h + \frac{1}{2}\rho v_{low}^2 = P_{up} + \rho \cdot g \cdot h + \frac{1}{2}\rho v_{up}^2$

$$\Rightarrow \quad P_{low} - P_{up} = \frac{1}{2}\rho v_{up}^2 - \frac{1}{2}\rho v_{low}^2$$

$$\Rightarrow \quad P_{low} - P_{up} = \frac{1}{2}\rho\left(v_{up}^2 - v_{low}^2\right)$$

$$\rho_{air} = 1.293 \ \frac{kg}{m^3}$$

$$\frac{2\,(P_{low} - P_{up})}{P_{air}} + v_{low}^2 = v_{up}^2$$

Further $P = \frac{F}{A} \implies F = \Delta P \cdot A$

$$\Delta P A - mg = 0$$

$$(P_{low} - P_{up}) = \Delta P = \frac{mg}{A} = 16'350 \text{ Pa}$$

$$V_{up} = \sqrt{\frac{2 \cdot \Delta P}{P_{air}} + v_{low}^2} = \sqrt{\frac{2 \cdot 16'350}{1.293 \frac{kg}{m^3}} + (95 \tfrac{m}{s})^2}$$

$$= \underline{\underline{185.2 \frac{m}{s}}}$$ ✓

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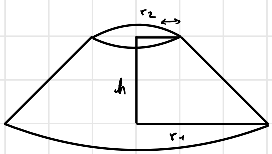
7. Truncated cone submerged




density $\rho$ , $L > h$

$\rho_L > \rho$

$$V = \frac{h\pi}{3}\left(R_1^2 + R_1 R_2 + R_2^2\right)$$

$F_L + F_{mg} = F_B \implies m \cdot g = \rho_L V g$ ✓ ✓ + ...

$$\implies V \rho \cdot g = \rho_L V g$$

$$\implies \rho = \rho_L$$

Very good!

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