Y13 Chapter 1-3 Quiz

TIP: draw a clear diagram for each situation.

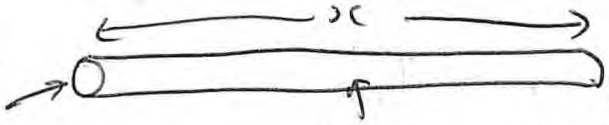
1. A person on a frictionless trolley shoots water horizontally from a fire extinguisher. The combined mass of the person, fire extinguisher and trolley is 100kg. The diameter of the nozzle is 1cm. 20 litres of water flows out in 10 seconds. What is the acceleration of the person on the trolley?

$a = \frac{F}{m}$ $F = \frac{\Delta p}{\Delta t} = v\frac{\Delta m}{\Delta t}$

I know that 1 litre of water has $m = 1kg$

$\frac{\Delta m}{\Delta t} = \frac{5kg}{10s} = 0.5 kgs^{-1}$

in 1 second



area is $\pi \times 0.5^2$

volume is $500cm^3$

$x \times$ area $=$ volume. $\therefore x = \frac{500cm^3}{\pi \times 0.5cm^2} = 636.6...cm$

so water goes 636 cm in 1 sec.

$\therefore v = 6.36 m/s$ $F = 6.36 \times 0.5 = 3.18N$ $a = \frac{3.18N}{100kg} = 0.032 m/s^2$

2. A spring has a spring constant of = 100 N/m and an original length of 10cm. The spring is compressed between two frictionless trolleys until its length is 2cm. Trolley A has a mass of 500g and trolley B has a mass of 1000g. The trolleys are released from rest. Find the speed that each trolley moves off at.

Energy in spring $= \frac{1}{2}k(\Delta L^2)$

$\Delta L = 8cm = 0.08m$. $\therefore E = \frac{1}{2} \times 100 \times (0.08^2)$

$= 0.32 J$

initial momentum is zero so final momentum is zero.

$\therefore m_A v_A = -m_B v_B$ $500 v_A = -1000 v_B$ $v_A = -2v_B$

must conserve energy.

$\frac{1}{2}m_A v_A^2 + \frac{1}{2}m_B v_B^2 = 0.32 J$. $m_A v_A^2 + m_B v_B^2 = 0.64 J$

$0.5kg \times v_A^2 + 1kg \times v_B^2 = 0.64 J$ $\therefore v_A^2 + 2v_B^2 = 1.28$

$(-2v_B)^2 + 2v_B^2 = 1.28$ $6v_B^2 = 1.28$ $v_B = 0.46 ms^{-1}$

$v_A = 0.92 ms^{-1}$

3. a) A 1kg mass is connected to a piece of copper wire with circular cross-section that is 1m long. The yield stress of copper is 70MPa. The wire is attached to a strong support so that the weight hangs vertically down.
What is the minimum diameter of the wire so that the copper does not yield?

$\sigma = F/A \quad A = F/\sigma \quad A = \pi r^2$

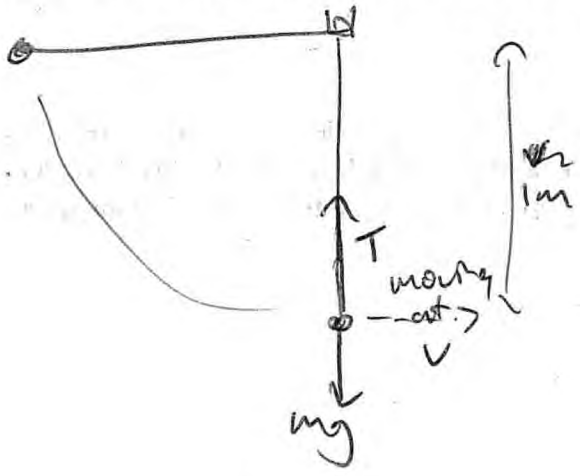
$\pi r^2 = F/\sigma \quad r^2 = \frac{F}{\sigma\pi} \quad r = \sqrt{\frac{F}{\sigma\pi}}$

$d = 2r = 2\sqrt{\frac{F}{\sigma\pi}} = 2\sqrt{\frac{1\times 9.81}{70\times10^6\times\pi}}$

$= 4.22\times10^{-4}\,m$

$= 0.42\,mm.$

b) The weight is then lifted up and to the side so that the wire is horizontal. The weight is released and swings in a circular arc.
What is the minimum diameter of the wire so that the copper does not yield now?



at bottom of swing,

$\frac{1}{2}mv^2 = mgh$

$\frac{1}{2}v^2 = gh$

$v^2 = 2gh.$

circular motion:

$F = T - mg = \frac{mv^2}{r} \qquad v^2 = 2gh$

so $T - mg = \frac{m\times 2gh}{r} \qquad r = h$ so $T - mg = 2mg$

$T = 3mg =$ ~~8~~ ∴ this is 3× T in part A

∴ area must be 3× larger so diameter must be $\sqrt{3}$ × larger so $\sqrt{3}\times 0.42 = 0.73\,mm$