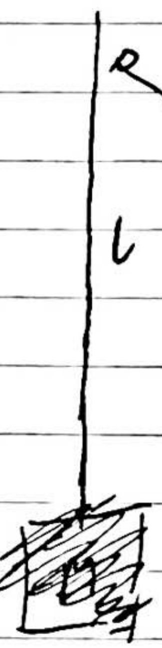
Q8:

$o \leftarrow$ small mass

$\frac{Mg}{m} L$



transverse pulse:

Tension $= \cancel{mg} \; \frac{L-x}{L} mg$

$\rho = \frac{m}{L}$

$c = \sqrt{\frac{T}{\rho}} = \sqrt{(L-x)g}$

$\dot{x} = \sqrt{(L-x)g} \qquad \frac{dx}{dt} = \sqrt{(L-x)(g)}$

The ball : $\ddot{x} = -g \quad \frac{dx}{dt} = -tg \quad x = -\frac{t^2}{2} g + c$

$\int \frac{dt}{dx} = \int \frac{-1}{\sqrt{(L-x)(g)}} dx \qquad t = +2\sqrt{L-x}\sqrt{g} + c$

$\left(\frac{t}{2\sqrt{g}}\right)^2 = L - x$

$x = L - \left(\frac{t}{2\sqrt{g}}\right)^2$

$\dot{x} = -\sqrt{xg} \qquad \int dt = \int \frac{1}{\sqrt{xg}}$

$t = 0 \quad x = L \qquad c = + 2\sqrt{Lg} \qquad t = 2\sqrt{xg} + c$

$t = 2(\sqrt{xg} - \sqrt{gL}) \qquad \left(t/2 + \sqrt{gL}\right)^2 =$

$x = L - \frac{t^2}{2} g$ for the falling body.

$\frac{dx}{dt} = -\sqrt{xg}$ $\quad \int_L^x \frac{1}{\sqrt{x}} dx = \int_0^t -\sqrt{g} dt$

$2\sqrt{x} - 2\sqrt{L} = -t\sqrt{g}$

$x = \cancel{2}\left(\sqrt{L} - \frac{t\sqrt{g}}{2}\right)^2$

$\left(\sqrt{L} - \frac{t\sqrt{g}}{2}\right)^2 = -\frac{t^2}{2} g + L$

$\cancel{\left(\frac{t\sqrt{g}}{\sqrt{2}}\right)^2 = \left(\sqrt{L} - \frac{t\sqrt{g}}{2}\right)}$

$\cancel{\sqrt{L} = \frac{\sqrt{2}+1\,(t\sqrt{g})}{2}}$ $\quad \cancel{t = \sqrt{\frac{L}{g}} \frac{2}{\sqrt{2}+1}}$

$\cancel{x = L - \frac{L\,4}{2(\sqrt{2}+1)^2}}$

$\frac{t^2 g}{4} + \frac{t^2 g}{2} - t\sqrt{L}\sqrt{g} = 0$

$\frac{3g}{4} t = \sqrt{L}\sqrt{g}$

$t = \frac{\sqrt{L}}{\sqrt{g}} \frac{4}{3}$

$x = L - L \frac{\left(\frac{16}{9}\right)}{2} = \frac{1}{9} L$

or $\frac{8}{9} L$ down.

now adding weight.

$x = L - \frac{t^2}{2}g$

$\frac{dx}{dt} = -\sqrt{xg + \frac{\mu g L}{m}}$

$\frac{t^2}{2}g = L$

$t = \sqrt{\frac{2L}{g}}$

$\int_L^x \frac{1}{\sqrt{x + \frac{\mu L}{m}}}\, dx = \int -\sqrt{g}\, dt$

$2\sqrt{x + \frac{\mu L}{m}} - 2\sqrt{L + \frac{\mu L}{m}} = -\sqrt{g}\, t$

$2\sqrt{\frac{\mu L}{m}} - 2\sqrt{L + \frac{\mu L}{m}} = -\sqrt{2L}$

$\mu = \frac{1}{8} m$

Q9.

diameter = 0.5 mm

length = 700 mm

ρ = 7800 kg m^{-3}

Y = 200 GPa so $\frac{\sigma}{\varepsilon}$ $\frac{\text{stress}}{\text{strain}}$

$\frac{T}{\rho} = v^2$

frequency = 261 Hz

λ = 1.4 m

$v = \lambda f$

$\rho = 7800 \times (\pi \times (0.00025)^2)$

$T = \rho \lambda^2 f^2$

$\rho = 1.53 \times 10^{-3}$ kg m^{-1}

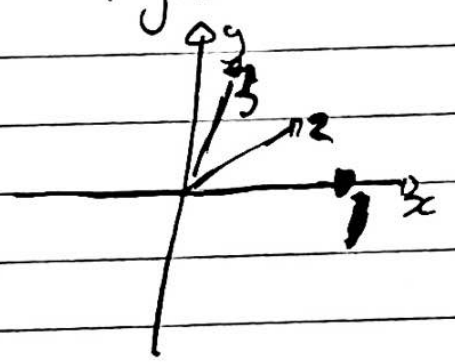
$T = 204$ N

-> which is $\approx$ 1 GPA.

This is a third of the yield

Q10. a) $\psi_{y,1} = a\sin\theta\cos(kz-\omega t+\phi_0)$

$\psi_{y,2} = b\cos(kz-\omega t-\frac{\pi}{2}) = b\sin(kz-\omega t)$



pointing towards source
so, y is $\frac{\pi}{2}$ behind.

$\psi_{y,3} = \frac{1}{2}c\sin(kz-\omega t)$

b) $\psi_{x,3} = \psi_{x,2} + \psi_1$

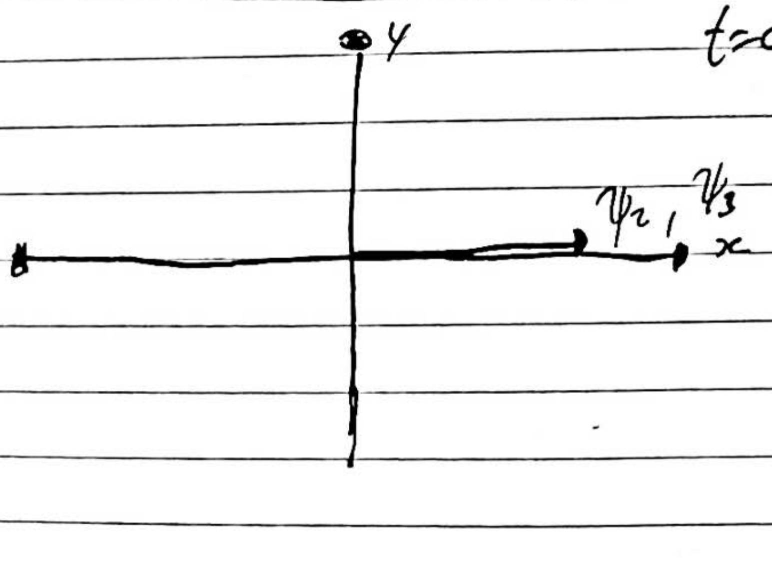
$a\cos\theta\cos(kz-\omega t+\phi_0) + b\cos(kz-\omega t) = c\cos(kz-\omega t)$

$\boxed{b = c, \quad \theta = \frac{\pi}{2}}$

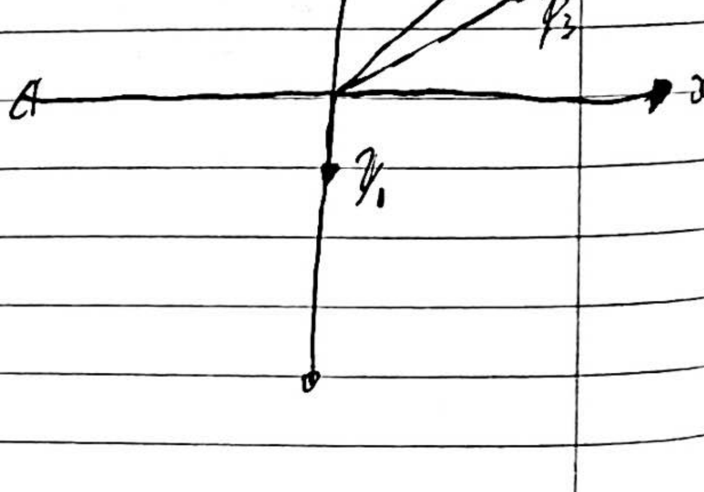
$\frac{1}{2}c\sin(kz-\omega t) = a\cos(kz-\omega t+\phi_0) + b\sin(kz-\omega t)$

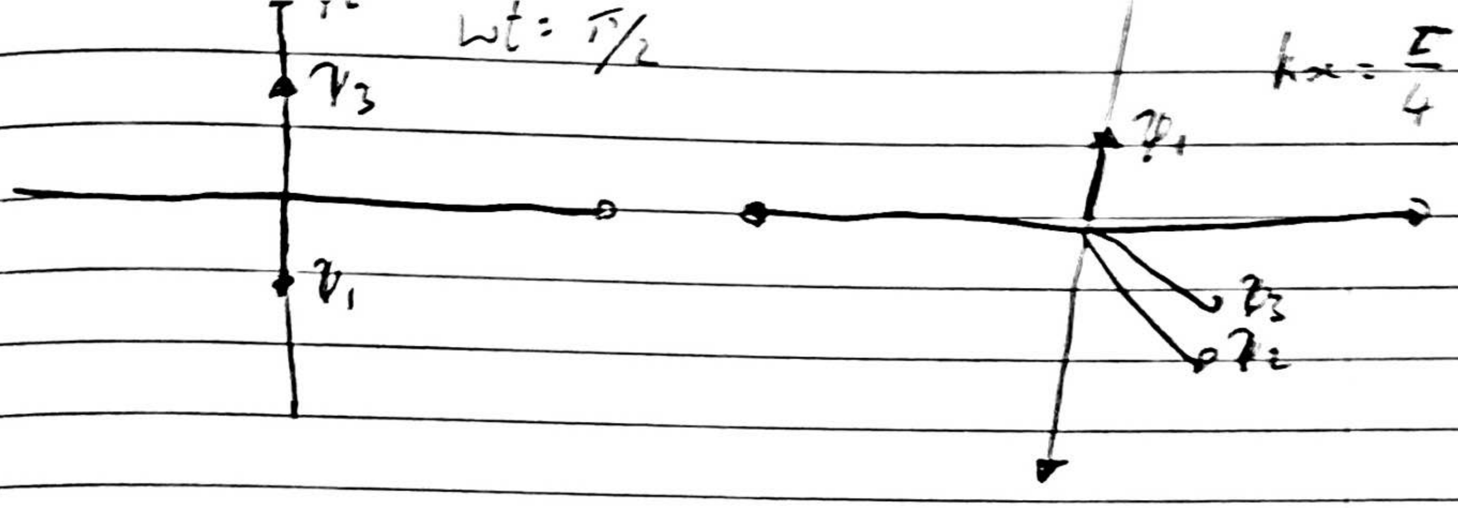
$\boxed{a = \frac{c}{2} \quad \phi_0 = +\frac{\pi}{2}}$

$t=0 \quad z=0$



$\omega t = \frac{\pi}{4}$

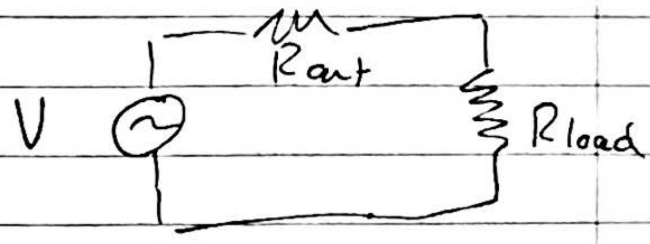




ωt = π/2
kx = π/4
ψ3
ψ1
ψ1
ψ3
ψ2

Example sheet for experimental methods.

1. a)



i)

$$V_{load} = V \frac{R_{load}}{R_{out} + R_{load}} \simeq V$$

ii) $$I = \frac{V}{R_{load} + R_{out}}$$

$$P = IV = \frac{V}{R_{load} + R_{out}} \times \frac{V R_{load}}{R_{out} + R_{load}}$$

$$P = \frac{V^2 R_{load}}{(R + R_{load})^2}$$

$$\frac{dP}{dR_{load}} = \frac{1}{(R + R_{load})^2} - 2\frac{R_{load}}{(R + R_{load})^3} = 0$$

$$R + R_{load} - 2R_{load} = 0 \quad \boxed{R_{load} = R_{out}}$$

If the receiving devise is an osiloscope, want accurate reading of power.

b)

at switch 1:

$$i_1 = \frac{V_{in}}{R} \qquad i_2 = \frac{V_{out}}{R}$$

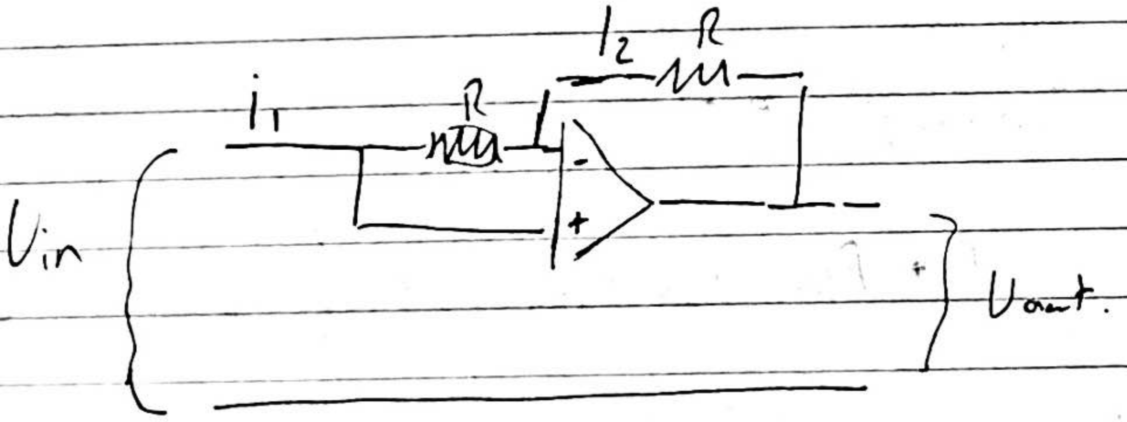
$i_1 = i_2 \therefore$ $V_{in} = V_{out}$ if the two resistors are equal.

Frequency should have no impact, as the impedance is not complex.

At position 2:

$V_- - V_+ = i_1 R$ so it is not zero.

that means that, the voltage



$$i_1 = \frac{V_{in} - V_-}{R} \qquad i_2 = \frac{V_- - V_{out}}{R}$$

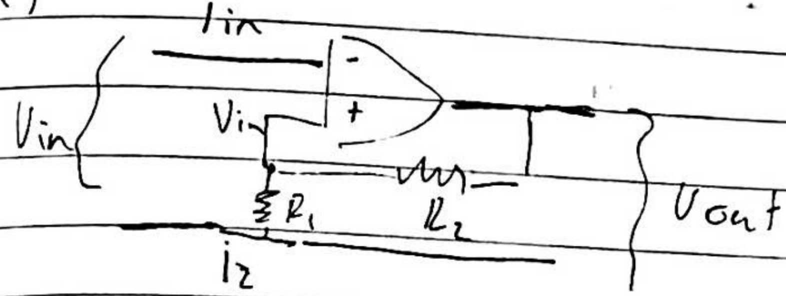
$$\frac{V_{in} - V_-}{R} = \frac{V_- - V_{out}}{R}$$

$$V_+ - \cancel{V_-} = V_{in} - \cancel{V_-}$$

$$V_+ = V_{in} \quad ?$$

1d)

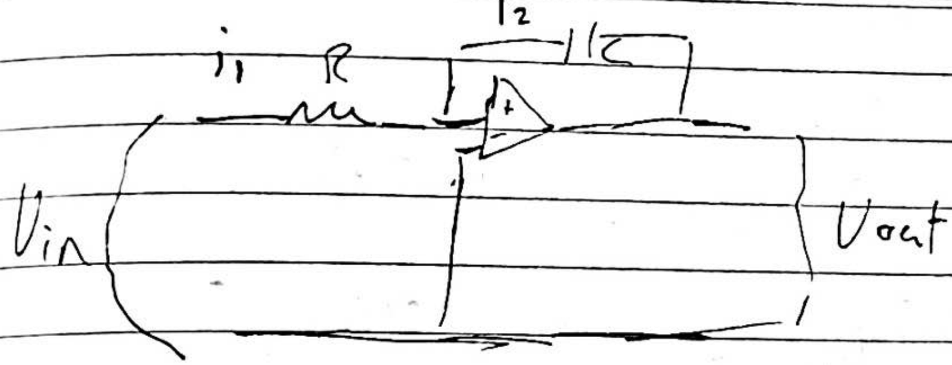
$i_{in} = 0$



$$\frac{V_{in} - V_{out}}{R_2} = i_2$$

$$\frac{V_{in}}{R_1} = \frac{V_{out} - V_{in}}{R_2} \qquad \frac{-V_{in}}{R_1} = i_2$$

$$V_{in}\left(\frac{R_2}{R_1} + 1\right) = V_{out} \qquad \frac{V_{out}}{V_{in}} = \left(1 + \frac{R_2}{R_1}\right)$$



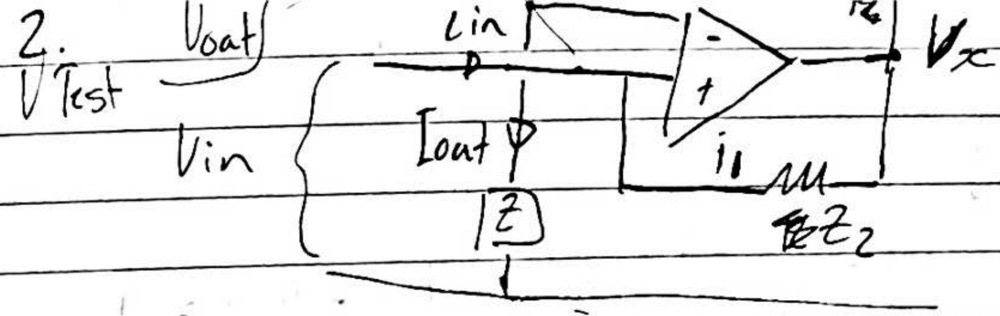
So analisis ~~would~~ gives $\frac{V_{out}}{V_{in}} = -i\frac{1}{R\omega C}$

$i_1 = \frac{V_{in} \cancel{- V_-}}{R}$

$i_2 = (\cancel{V_-} - V_{out})(i\omega C)$

~~So current is~~
So voltage depends on the fregnency.

2.



$$Z_{in} = \frac{V_{in}}{I_{in}} \quad ①$$

golden rule 2:

$$V_+ = V_- = V_{in} \quad ②$$

$$I_{out} = \frac{V_{out}}{Z_3} = \frac{V_{in}}{Z_3} \quad ③$$

then $I_{in} = \dfrac{V_{in} - V_x}{Z_2}$

$$V_x = \frac{Z_1 + Z}{Z} V_{in}$$

$$I_{in} = V_{in}\left(\frac{1 - \frac{Z_1 + Z}{Z}}{Z_2}\right)$$

$$= V_{in}\left(\frac{-Z_1}{Z Z_2}\right)$$

$$Z_{in} = -\frac{Z Z_2}{Z_1}$$

now replace:

$$Z_{in} = -\frac{\cancel{R}\left(\frac{1}{i\omega c}\right)}{\cancel{R}}$$

$$Z_{in} = i\frac{1}{\omega c}$$

so Voltage is ahead of current.