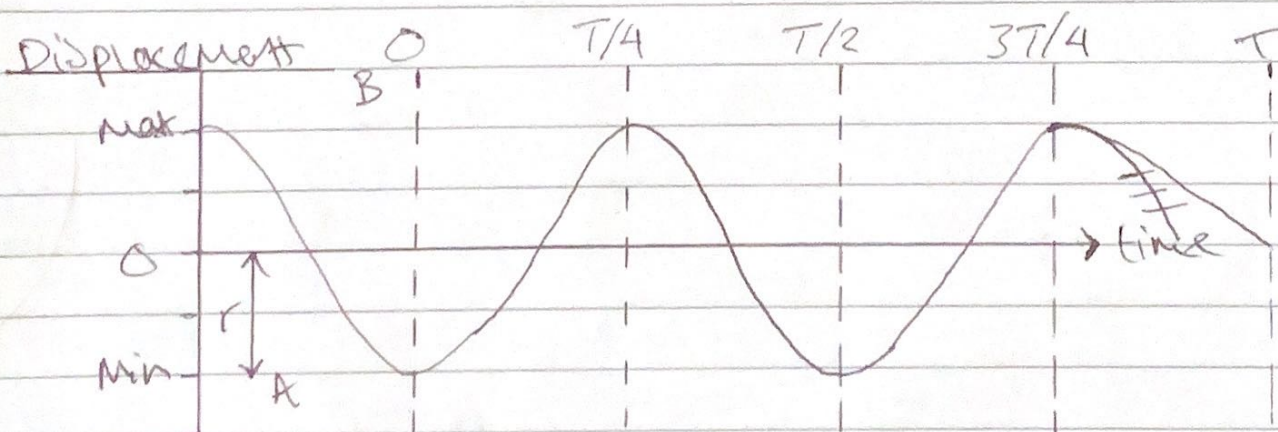
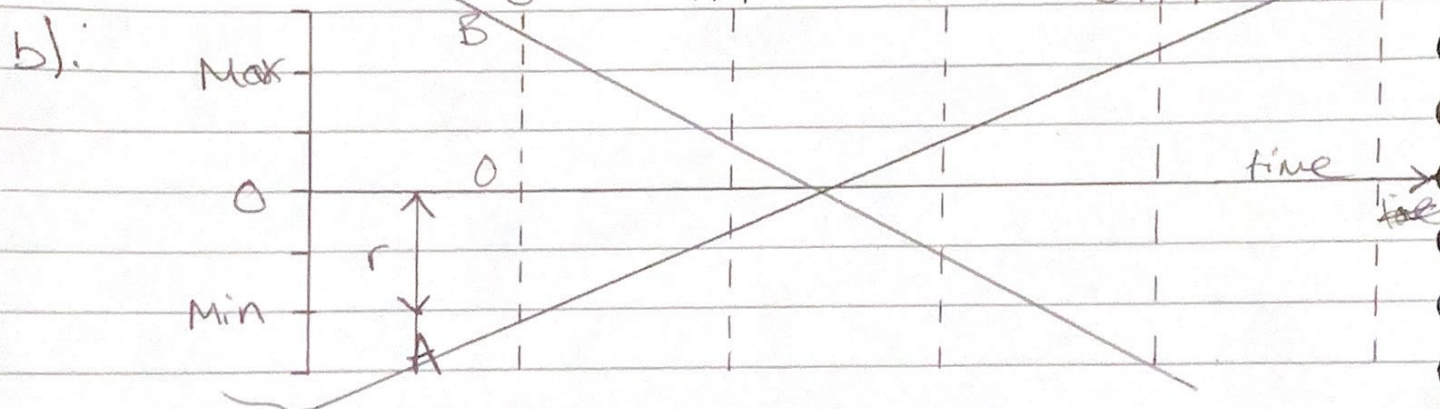


Q2). a). Simple harmonic motion is a special periodic movement in which the acceleration of a body is always directed towards one point in its path.

As well as the magnitude of the acceleration of a body is proportional to the distance from the fixed point.

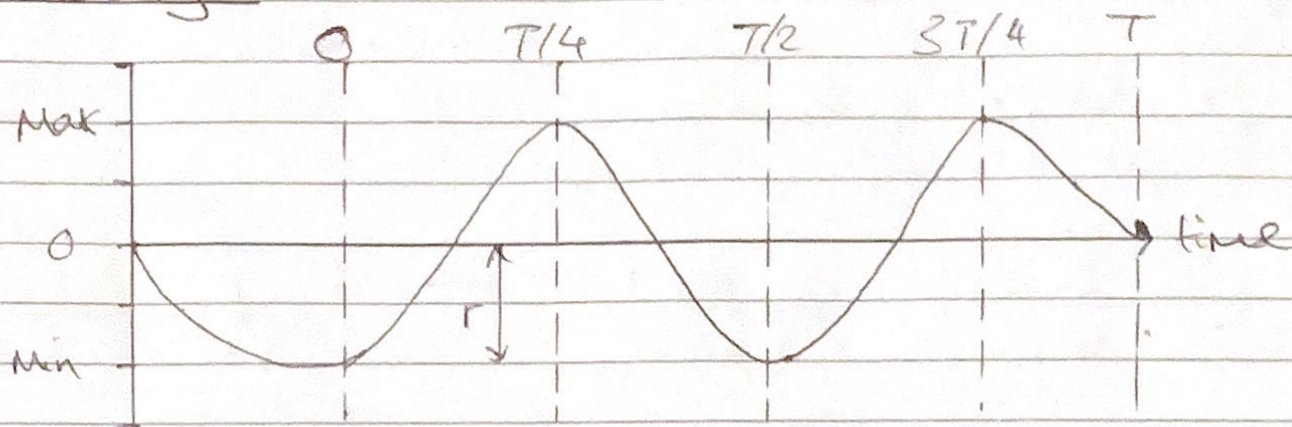


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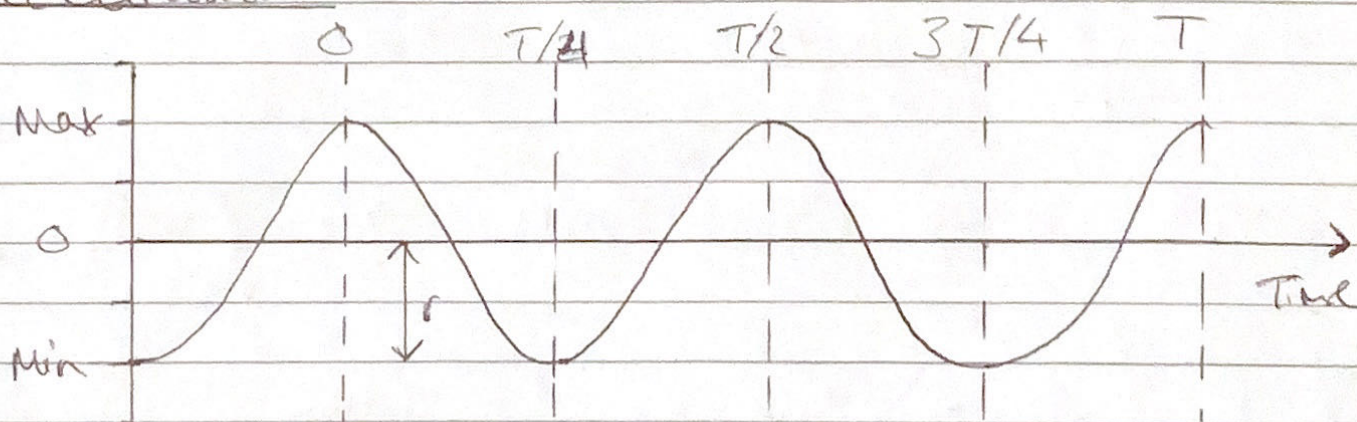
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Velocity



Acceleration



~~$$c). V = \omega \sqrt{r^2 - x^2}$$~~

~~$$V_1 = 15 \text{ m/s} ; V_2 = 3 \text{ m/s}$$~~

~~$$x_1 = 0.08 \text{ m} \quad x_2 = 0.16 \text{ m}$$~~

~~$$15 = \omega \sqrt{r^2 - 0.0064}$$~~

~~(1)~~

~~$$3 = \omega \sqrt{r^2}$$~~

~~$$3 = \omega \sqrt{r^2 - 0.0256}$$~~

~~(2)~~

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$$c) i) V = \omega \sqrt{r^2 - x^2}$$

$$V_1 = 15 \text{ m/s} ; V_2 = 3 \text{ m/s}$$

$$x_1 = 0.08 \text{ m}$$

$$x_2 = 0.16 \text{ m}$$

$$15 = \omega \sqrt{r^2 - 0.0064} \quad (1)$$

$$3 = \omega \sqrt{r^2 - 0.0256} \quad (2)$$

$$15 = \omega \sqrt{r^2 - 0.0064}$$

$$3 = \omega \sqrt{r^2 - 0.0256}$$

$$\frac{15}{3} = \frac{\omega \sqrt{r^2 - 0.0064}}{\omega \sqrt{r^2 - 0.0256}} \Rightarrow 5 = \frac{\sqrt{r^2 - 0.0064}}{\sqrt{r^2 - 0.0256}}$$

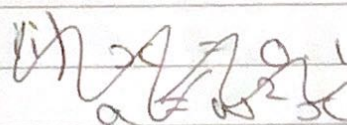
Square both sides,

$$25 = \frac{r^2 - 0.0064}{r^2 - 0.0256}$$

$$25r^2 - 0.64 = r^2 - 0.0064 \rightarrow r = \sqrt{\frac{0.6336}{24}}$$

$$r = 0.16$$

$$r = \underline{162.5 \text{ mm}} \leftarrow \text{Amplitude of oscillation}$$

ii)  Finding Frequency...

$$15 = \omega \sqrt{0.0264 - 0.0064}$$

↑
Amplitude Squared

$$\omega = 15$$

$$\omega = 106 \text{ rad/s}$$

$$\sqrt{0.0264 - 0.0064}$$

$$f = \omega / 2\pi \rightarrow 106 / 2\pi = \underline{16.9 \text{ Hz}}$$

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ii) ~~Maximum~~ Acceleration at mid

$$x = 0.12 \text{ m}$$

$$a = \omega^2 x$$

$$a = (106)^2 \times (0.12) = 1348.32 \text{ m/s}^2$$

Maximum Acceleration

~~where~~ $x = r \leftarrow \text{Max Acceleration}$

$$r = 162.5 \text{ mm} \rightarrow x = 162.5 \text{ mm}$$

$$a = \omega^2 x$$

$$a = (106)^2 \times (0.162) = 1820.232 \text{ m/s}^2$$

$$\text{Maximum Acceleration} = \underline{1820.23 \text{ m/s}^2}$$

d). Aluminium alloy will be used due to the significant stresses. Using a low mass material reduces the stresses.

Stresses will be present due to high acceleration.

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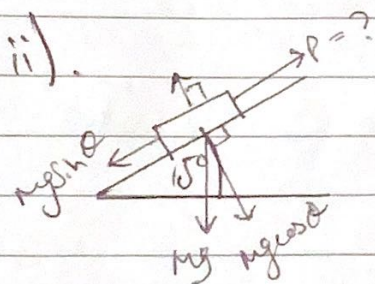
Q4) a). Cold - welding is the process of joining two or more metals together without heat or fusion processes. Instead it welds together through extreme pressure on ~~one~~ each other.

b) i) mass = 350 kg
Force = 1.15 kN

$$F_f = \mu \times R_N \rightarrow \therefore \mu = \frac{F_f}{R_N}$$

Assuming that $F_f = P \rightarrow \therefore \mu_s = \frac{P}{R_N}$

$$\mu_s = \frac{1150}{mg} = \frac{1150}{(350 \times 9.81)} = 0.335$$



Resolve Forces Perpendicular to plane:

$$R_N = mg \cos \theta$$

$$R_N = 350 \times 9.81 \times \cos 15$$

$$R_N = 3316.5 \text{ N}$$

$$P = mg \sin \theta + F_f = mg \sin \theta + \mu \times R_N \quad \leftarrow = \mu mg \cos \theta$$

$$P = mg \sin \theta + \mu mg \cos \theta$$

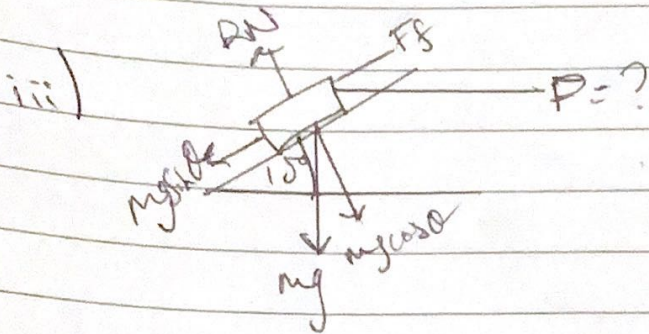
$$P = (350 \times 9.81) \sin(15) + 0.335 \times (350 \times 9.81) \cos(15)$$

$$P = 1999.68 \text{ N}$$

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$$R_N = mg \cos \theta + P \sin \theta \quad \leftarrow \text{perpendicular}$$

$$P \cos \theta + \mu \times R_N = mg \sin \theta$$

$$P \cos \theta + \mu \times P \sin \theta = mg \sin \theta - \mu \times mg \cos \theta$$

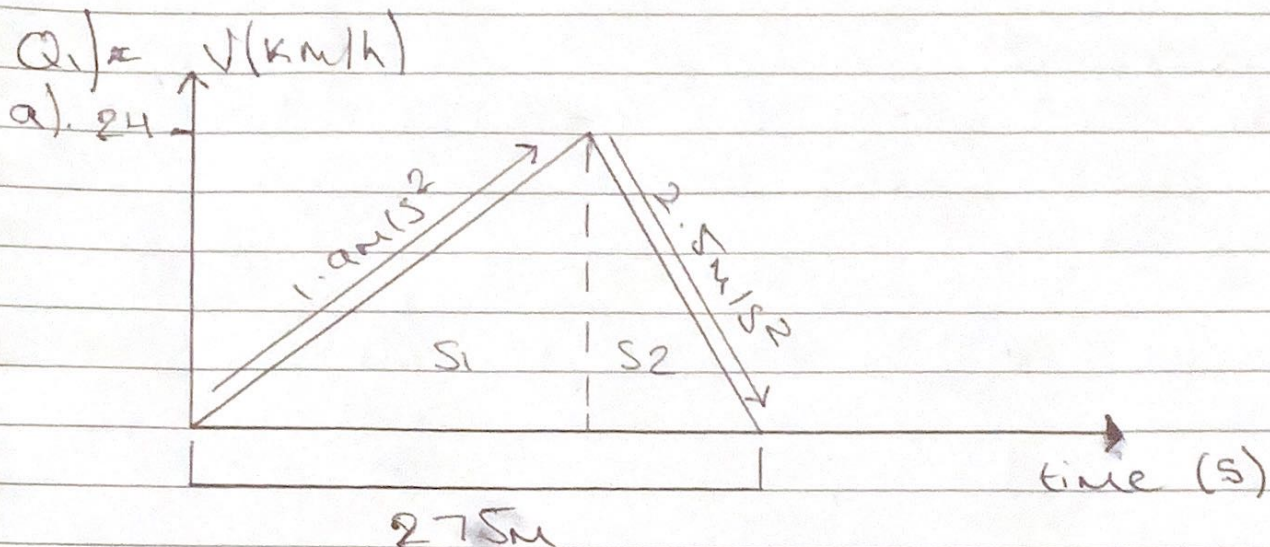
$$\therefore P = \frac{mg (\sin \theta - \mu \cos \theta)}{(\cos \theta + \mu \sin \theta)}$$

$$P = \frac{350 \times 9.81 (\sin(15) - 0.335 \cos(15))}{(\cos(15) + 0.335 \sin(15))}$$

$$P = \underline{\underline{2095.2 \text{ N}}}$$

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b) $24 \times \frac{1000}{3600} = 6.67 \text{ m/s}$

Looking at 'S1'

$$V = U + at \rightarrow \frac{V - U}{a} = t \rightarrow t = \frac{6.67 - 0}{1.9}$$

$t = 3.51 \text{ s}$

Looking at 'S2'

$$V = U + at \rightarrow \frac{V - U}{a} = t \rightarrow t = \frac{0 - 6.67}{2.5}$$

$t = 2.668 \text{ s}$

Total time = 6.178s

Assumptions:

Vehicle was at rest
from beginning to end

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(c). ~~Values~~ Given:

$$V_{\max} = \frac{27.5 \times 1000}{3600} = 7.64 \text{ m/s}$$

Looking at 's1'

$$V = U + at \rightarrow \frac{V - U}{a} = t \rightarrow t = \frac{7.64 - 0}{1.9}$$

$$t = 4.02 \text{ s}$$

Looking at 's2'

$$V = U + at \rightarrow \frac{V - U}{a} = t \rightarrow t = \frac{0 - 7.64}{2.5}$$

$$t = 3.06 \text{ s}$$

$$\text{Total time} = 7.08 \text{ s}$$

End