

1.

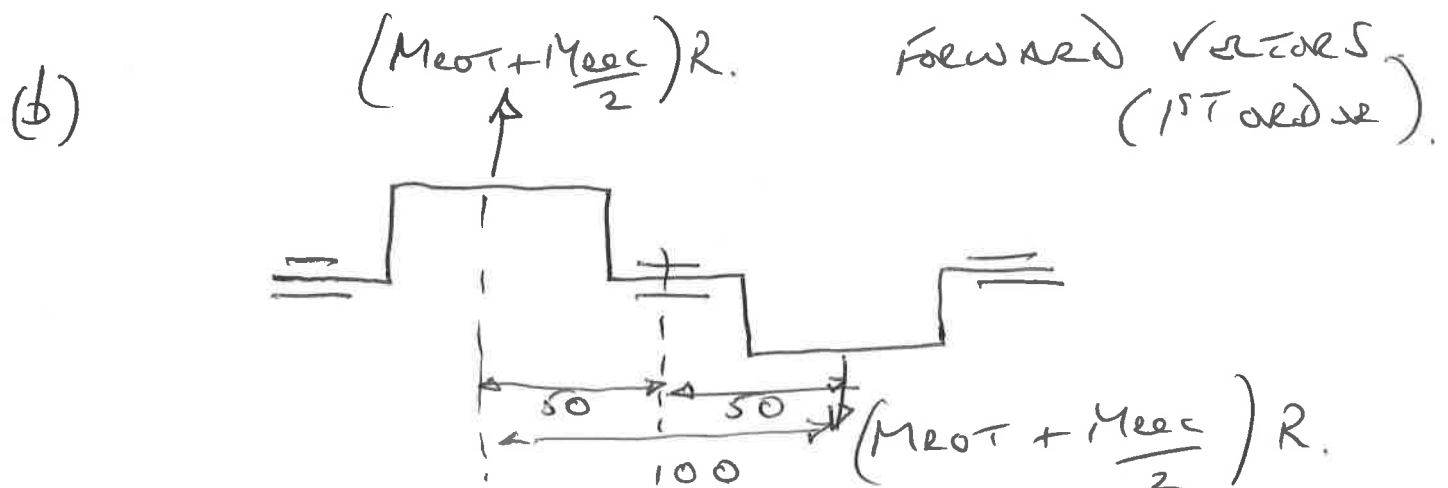
AUGUST 2015.

Q 3. PISTON + PIN MASS = 340 gms.
 ROD MASS = 390 gms.
 STROKE = 60 mm.
 BALANCE CRANK SPACER = 100 mm.

$$M_{ROT.} = \frac{2}{3} \times 390 = 260 \text{ gms} \\ = 0,26 \text{ kg.}$$

$$M_{REC} = 340 + \frac{1}{3} \times 390 \\ = 470 \text{ gms} = 0,47 \text{ kg.}$$

(a) BOB WEIGHT MASS = $M_{ROT.} + \frac{M_{REC}}{2}$
 $= 0,26 + \frac{0,47}{2}$
 $= \underline{\underline{0,495 \text{ kg.}}}$



2. MOMENT OF FORWARD MASS MOMENTS
IN PLANE OF CRANKPINS ABOUT CENTRE

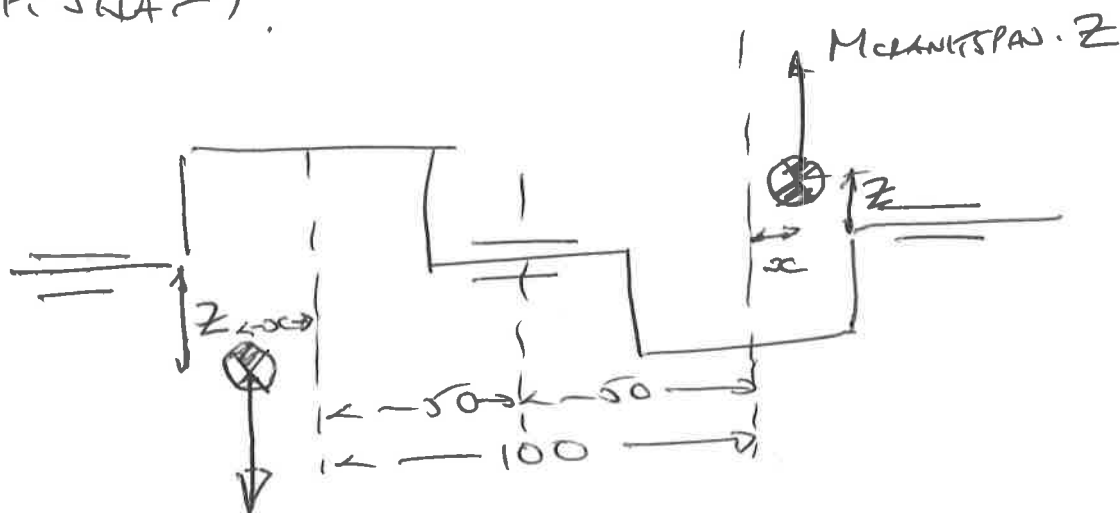
$$= (M_{\text{rot}} + \frac{M_{\text{rec}}}{2}) R \times 50$$

$$= \left(M_{\text{rot}} + \frac{M_{\text{rec}}}{2} \right) R \times 100$$

$$= 0,495 \times 30 \times 100$$

= 1485 \text{ fig. mm. mm.}

LOOK AT RESTORING MOMENTS FROM
CRANK SHAFT.



McIntosh. Z

Масса воды. $Z = 3 \times 3 = 9 \text{ кг. м.м.}$

RESTORING MOMENT ABOUT CENTER

$$= M_{\text{chlorophyll } a} \cdot Z \times (50+x) + M_{\text{chlorophyll } b} \cdot Z \times (50+x)$$

3.

$$= 2 \cdot \text{MOMENTS} \cdot Z \cdot (50 + x)$$

$$= 2 \times 9 \times (50 + x)$$

$$= 18 \times (50 + x) = 900 + 18x$$

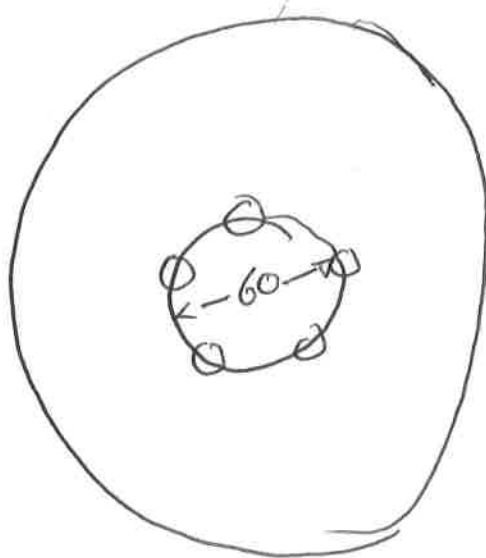
TO BALANCE MOMENTS MAKE

$$1485 = 900 + 18x$$

$$585 = 18x$$

$$x = \frac{585}{18} = \underline{\underline{32,5 \text{ mm.}}}$$

(c)



GRADE 10,9 BOLT HAS YIELD

$$= 0,9 \times 1000 = 900 \text{ N/mm}^2$$

4.

$$\begin{aligned}\text{TIGHTEN TO} & 90\% \text{ YIELD} \\ \text{AXIAL STRESS} & = 60\% \text{ YIELD} \\ & = 0,6 \times 900 \\ & = 540 \text{ N/mm}^2.\end{aligned}$$

$$\begin{aligned}\therefore \text{CLAMPING FORCE} & = 540 \times \frac{\pi \times 8^2}{4} \\ & = 27147 \text{ N}.\end{aligned}$$

$$\begin{aligned}\text{FRICTION FORCE PER BOLT} & \\ & = 0,1 \times 27147 \\ & = 2714,7 \text{ N}.\end{aligned}$$

$$\text{IF MAX TORQUE} = 120 \text{ Nm}.$$

$$\begin{aligned}\text{ASSUME SHOCK LOAD} & = 2 \times 120 \\ & = 240 \text{ Nm}\end{aligned}$$

$$\text{ASSUME SAFETY FACTOR} = 2$$

TO GIVE MAXIMUM DESIGN

$$\begin{aligned}\text{TORQUE} & = 2 \times 240 \\ & = 480 \text{ Nm}.\end{aligned}$$

5.

$$= 480000 \text{ Nm.}$$

IF THERE ARE N BOLTS

TOTAL REACTION TORQUE =

$$= N \times 2714,7 \times 30$$

(TWO MOMENTS
ABOUT CENTRE)

$$\therefore 480000 = N \times 2714,7 \times 30.$$

$$N = 5,89$$

USE 6 BOLTS.

7. QUESTION 4.

$$\text{Piston mass} = 250 \text{ gms.}$$

$$\text{Rod mass} = 300 \text{ gms.}$$

$$\text{Rod length} = 120 \text{ mm.}$$

$$\text{Stroke} = 70 \text{ mm.}$$

$$\text{Given } M_{\text{rot}} = \frac{2}{3} \times 300 = 200 \text{ gms}$$

$$= \underline{\underline{0,2 \text{ kg}}}$$

$$M_{\text{rec}} = 250 + \frac{1}{3} \times 300$$

$$= 350 \text{ gms} = \underline{\underline{0,35 \text{ kg}}}$$

4 Identical mounts.

(a) Let stiffness of each mount = k
Total stiffness of 4 mounts
in parallel = $4k = K$.

If engine-gearbox mass = 140 kg

$$\begin{aligned} \text{Vertical force on 3g Bomp} \\ &= 3 \times 140 \times 9,81 \\ &= \underline{\underline{4120,2 \text{ N.}}} \end{aligned}$$

8. IF TOTAL DEFLECTION = 10mm

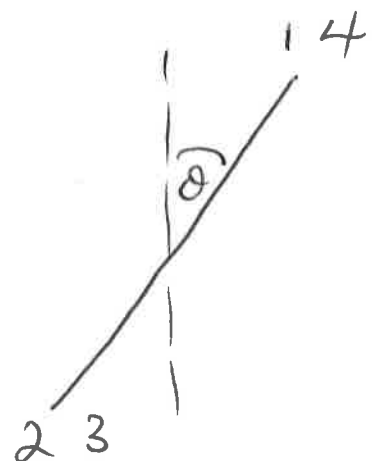
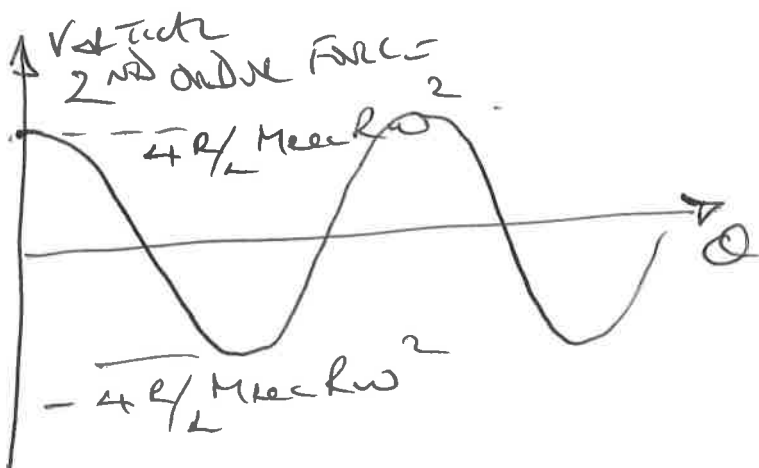
$$\text{TOTAL STIFFNESS} = 4120,2.$$

$$\begin{aligned} &= \frac{10}{10} \\ &= 412 \text{ N/mm.} \\ &= 412 \times 10^3 \text{ N/m.} \end{aligned}$$

$$\text{STIFFNESS OF EACH MOUNT} = 3$$

$$\begin{aligned} &= \frac{412 \times 10^3}{4} \\ &= 103 \times 10^3 \text{ N/m.} \end{aligned}$$

(b) AN INCLINE ~~FOUR~~ FOUR CYLINDER HAS TOTAL VERTICAL SECOND ORDER FORCE = $4 \frac{R}{L} M_{\text{rec}} \cdot 2 \cdot \omega^2 \cos 2\theta$.



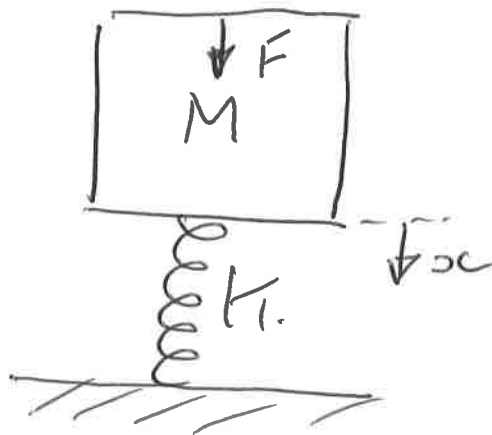
a. Steady state amplitude =

$$= \frac{4R}{L} M_{rec} \cdot R \omega^2$$

$$= \frac{4 \times 0,035}{0,12} \times 0,35 \times 0,035 \omega^2$$

$$= 0,014 \omega^2 \text{ N.}$$

(c)



$$F = F_0 \cos 2\omega t$$

$$= F_0 \cos 2\omega t$$

(ω = Angular velocity in rads/sec)

Put $x = x_0 \cos 2\omega t$.

(same resonance)

Equation of motion becomes

$$F - K \cdot x = M \cdot \frac{d^2 x}{dt^2}$$

$$F_0 \cos 2\omega t - K \cdot x_0 \cos 2\omega t = M \cdot \frac{d^2}{dt^2} (x_0 \cos 2\omega t)$$

10. DIFFERENTIATING

$$x = x_0 \cos 2\omega t$$

$$\frac{dx}{dt} = -2\omega x_0 \sin 2\omega t$$

$$\frac{d^2x}{dt^2} = -4\omega^2 x_0 \cos 2\omega t$$

SUBSTITUTE IN EQUATION OF MOTION
TO GIVE

$$F_0 \cos 2\omega t - kx_0 \cos 2\omega t = -4M\omega^2 x_0 \cos 2\omega t$$

$$F_0 - kx_0 = -4M\omega^2 x_0$$

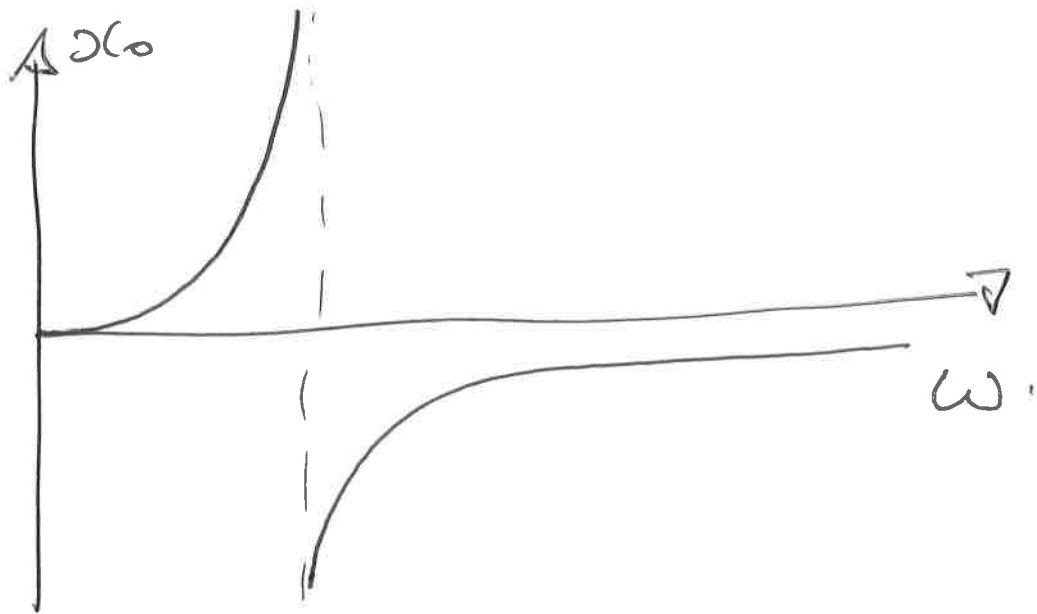
$$\begin{aligned} F_0 &= kx_0 - 4M\omega^2 x_0 \\ &= (k - 4M\omega^2) x_0 \end{aligned}$$

$$x_0 = \frac{F_0}{(k - 4M\omega^2)}$$

$$= \frac{0,014 \omega^2}{(412 \times 10^3 - 4 \times 140 \omega^2)}$$

11.

$$x_0 = \frac{0,014 \omega^2}{(412 \times 10^3 - 560 \omega^2)}$$



(d) Vertical resonance is when $x_0 \rightarrow \infty$ and $(412 \times 10^3 - 560 \omega^2) = 0$

$$\begin{aligned} \text{i.e. } 560 \omega^2 &= 412 \times 10^3 \\ \omega^2 &= \frac{412 \times 10^3}{560} \end{aligned}$$

$$\omega = 27,1 \text{ RAD/s/sec.}$$

12.

$$\text{RPM} = 60 \times \frac{\omega}{2\pi}$$

$$= \underline{\underline{259.}}$$

$$\left(\text{No. of rev/sec} = \frac{\omega}{2\pi} \right)$$

(e). AT HAT RPM

$$560 \omega^2 \Rightarrow 412 \times 10^3$$

$$\text{or } 412 \times 10^3 \text{ cm}$$

BE TOWER

∴ AT HAT RPM

$$\omega_0 = \frac{0,014 \cancel{\omega^2}}{560 \cancel{\omega^2}}$$

$$= 2,5 \times 10^{-5} \text{ m}$$

$$= 2,5 \times 10^{-2} \text{ mm}$$

$$= \underline{\underline{0,025 \text{ mm.}}}$$