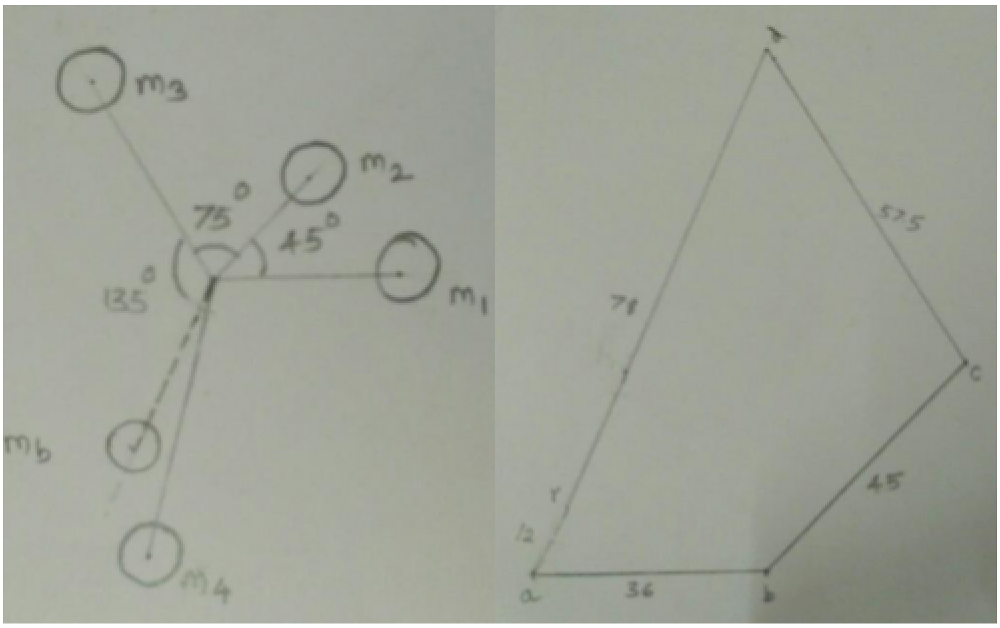
Four masses attached to a shaft and their respective radii of rotation are given as : m 1 = 180 kg m 2 = 300 kg m 3 = 230 kg m 4 = 260 kg r 1 = 0.2 m r 2 = 0.15 m r 3 = 0.25 m r 4 = 0.3 m The angles between successive masses are 45□, 75□ and 135□. Find th

Given : m1 = 180 kg, m2 = 300 kg, m3 = 230 kg, m4 = 260 kg r1 = 0.2 m, r2 = 0.15 m, r3 = 0.25 m, r4 = 0.3 m ϴ1 = 45, ϴ2 = 75, ϴ = 135 The centrifugal forces are given by - m1r1 = 36, m2r2 = 45, m3r3 = 57.5, m4r4 = 78



a) Space diagram b) Vector diagram

From vector diagram the resultant force is at 60 to the mass m1 and is represented by ar ar = 12 kg m Therefore mb * rb = 12 kgm Balancing mass mb = 12/0.2 = 60 kg at an angle of 2400 with the direction of m1 mass

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Write the procedure for balancing of a single rotating mass by single masses rotating in the same plane.

Procedure :Balancing of a Single Rotating Mass By a Single Mass Rotating in the Same Plane Consider a disturbing mass m1 attached to a shaft rotating at ω rad/s as shown in Fig. Let r1 be the radius of rotation of the mass m1 (i.e. distance between the axis of rotation of the shaft and the centre of gravity of the mass m1). We know that the centrifugal force exerted by the mass m1 on the shaft, FCl= m1.ω2 . r1 . . . (i) This centrifugal force acts radially outwards and thus produces bending moment on the shaft.

Why is balancing of rotating parts necessary for high speed engines ?

Reasons for balancing of rotating elements of machine: The balancing of the moving parts both rotating and reciprocating of such machine is having greater importance. Because, if these parts are not balanced properly then the unbalanced dynamic forces can cause serious consequences, which are harmful to the life of the machinery itself, the human beings and all the property around them. These unbalanced forces not only increase the load on the bearings and stresses in various members, but also produces unpleasant and dangerous vibrations in them.

Three masses 10 kg, 20 kg and 15 kg are attached at a point at radii of 20 cm………

Given : $m_1 = 10$ kg ; $m_2 = 20$ kg ; $m_3 = 15$ kg ;

$r_1 = 0.2$ m ; $r_2 = 0.25$ m; $r_3 = 0.15$ m; $r = 0.30$m

$\theta_1 = 0°$; $\theta_2 = 60°$; $\theta_3 = 150°$

Let m = Balancing mass, and

θ = The angle which the balancing mass makes

Since the magnitude of centrifugal forces are proportional to the product of each mass and its radius,

therefore

$m_1 \cdot r_1 = 10 \times 0.2 = 2$ kg-m

$m_2 \cdot r_2 = 20 \times 0.25 = 5$ kg-m

$m_3 \cdot r_3 = 15 \times 0.15 = 2.25$ kg-m

Resolving $m_1.r_1$, $m_2.r_2$, $m_3.r_3$ and $m_4.r_4$ horizontally,

$$\Sigma H = m_1 \cdot r_1 \cos\theta_1 + m_2 \cdot r_2 \cos\theta_2 + m_3 \cdot r_3 \cos\theta_3$$

$$= 2 \cos 0° + 5 \cos 60° + 2.25 \cos 150°$$

$$= \boxed{2.55 \text{ kg-m}}$$

Now resolving vertically,

$$\Sigma V = m_1 \cdot r_1 \sin\theta_1 + m_2 \cdot r_2 \sin\theta_2 + m_3 \cdot r_3 \sin\theta_3$$

$$= 2 \sin 0° + 5 \sin 60° + 2.25 \sin 150°$$

$$= \boxed{5.455 \text{ kg-m}}$$

$\therefore$ Resultant, $R = \sqrt{(\Sigma H)^2 + (\Sigma V)^2} = \boxed{6.02 \text{ kg-m}}$

We know that

$m \cdot r = R = 6.02$ $\quad$ m = 6.02 / 0.30 = 20.067 kg

and $\tan\theta' = \Sigma V / \Sigma H$ = $\boxed{\theta' = 64.94°}$

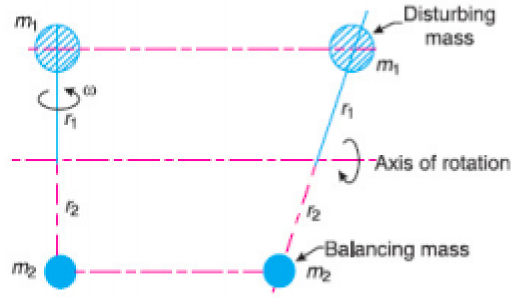
Write the procedure for balancing of a single rotating mass by single masses rotating in the same plane.

Consider a disturbing mass m_1 attached to a shaft rotating at ω rad/s as shown in Fig. 21.1. Let r_1 be the radius of rotation of the mass m_1 (*i.e.* distance between the axis of rotation of the shaft and the centre of gravity of the mass m_1).

We know that the centrifugal force exerted by the mass m_1 on the shaft,

$$F_{C1} = m_1 \cdot \omega^2 \cdot r_1 \quad \ldots (i)$$

This centrifugal force acts radially outwards and thus produces bending moment on the shaft. In order to counteract the effect of this force, a balancing mass (m_2) may be attached in the same plane of rotation as that of disturbing mass (m_1) such that the centrifugal forces due to the two masses are equal and opposite.



Balancing of a single rotating mass by a single mass rotating in the same plane.

Let r_2 = Radius of rotation of the balancing mass m_2 (*i.e.* distance between the axis of rotation of the shaft and the centre of gravity of mass m_2).

$\therefore$ Centrifugal force due to mass m_2,

$$F_{C2} = m_2 \cdot \omega^2 \cdot r_2 \quad \ldots (ii)$$

Equating equations (*i*) and (*ii*),

$$m_1 . \omega^2 \cdot r_1 = m_2 \cdot \omega^2 \cdot r_2 \quad \text{or} \quad m_1 \cdot r_1 = m_2 \cdot r_2$$

Why is balancing of rotating parts necessary for high speed engines ?

The high speed of engines and other machines is a common phenomenon now-a-days. It is, therefore, very essential that all the rotating and reciprocating parts should be completely balanced as far as possible. If these parts are not properly balanced, the dynamic forces are set up.

A rotor having the following properties………

Data :

m1= 4 kg	r1= 75 mm	$\theta 1 = 45^{o}$	m1r1= 300 kg-mm
m2= 3kg	r2= 85 mm	$\theta 2 = 135^{o}$	m2r2 = 265 kg-mm
m3= 2.5 kg	r3= 50 mm	$\theta 3 = 240^{o}$	m3r3 = 125 kg-mm

Radius of balance mass = r = 75 mm

Let m=Balancing mass

Resolving horizontally,

$$\sum H = m1r1cos\theta1 + m2r2cos\theta2 + m3r3cos\theta3$$

$= 300\cos 45^{o} + 265 \cos 135^{o} + 125 \cos 240^{o}$

$= -37.87$ kg-mm [1 M]

Resolving vertically,

$$\sum V = m1r1sin\theta1 + m2r2sin\theta2 + m3r3sin\theta3$$

$= 300\sin 45^{o} + 265 \sin 135^{o} + 125 \sin 240^{o}$

291.25 kg-mm [1M]

Resultant R= $\sqrt{(\Sigma H)^2 + (\Sigma V)^2}$

$= \sqrt{(-37.87)^2 + (291.25)^2}$

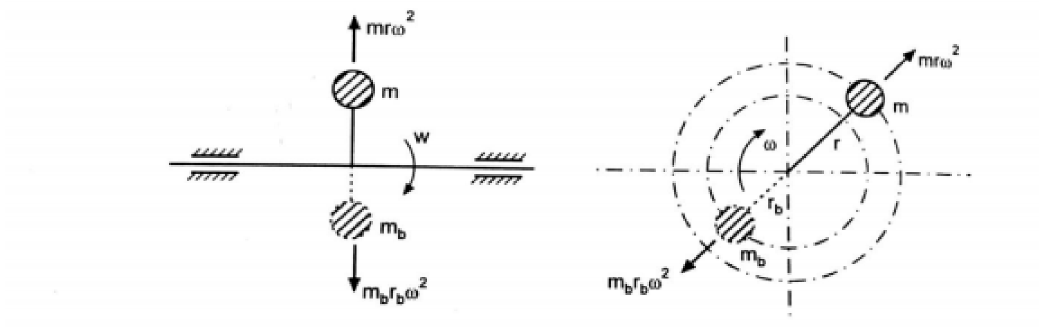
= 293.70 kg-mm

We know that

m X r = R

$m = \frac{293.70}{75} = 3.91$ kg ……**counterbalance** mass [2 M]

Write the procedure of balancing single rotating mass when it balance mass is rotating in the same plane as that of disturbing mass.



(a) Longitudinal positions of masses (b) Angular positions of masses

…………… [2M]

Fig. shows single rotating mass 'm' which is attached to a shaft rotating with angular velocity 'ω'.

Let 'r' = distance of centre of gravity of 'm' from axis of rotation of shaft. Due to rotation of shaft, centrifugal force '$mr\omega^2$ 'acts radially outwards due to inertia of mass. This force is called disturbing force which will produce bending moment on the shaft.

A balance mass m_b is introduced in the plane of rotation of disturbing mass, such that, it neutralizes the effect of inertia force due to disturbing mass.

Thus , the inertia forces of mass 'm' and mass 'm_b' must be equal and opposite.

$$mr\omega^2 = m_b r_b \omega^2$$

$$mr = m_b r_b.$$

Thus the balancing mass m_b is used at convenient radius r_b .Generally, r_b is considered as large as possible so that balance mass m_b required is very small. ….[2 M]

Explain the process of balancing of single rotating mass by a single mass rotating in the same plane.

m = Mass attached to shafts,

r = Distance of CG from axis of rotation.

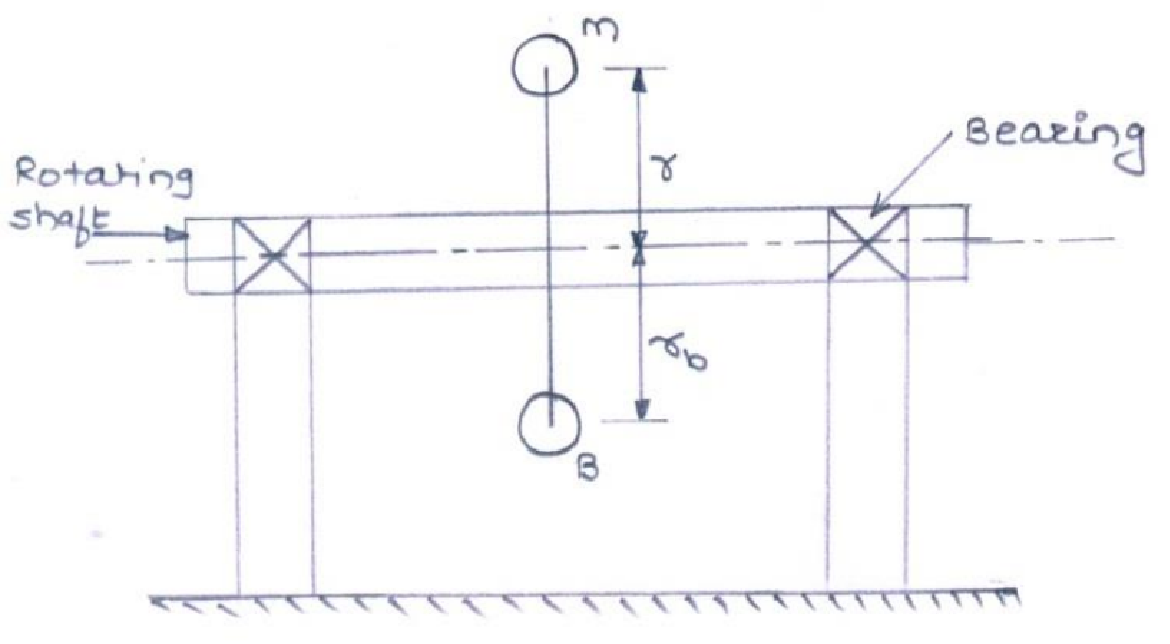
Consider mass 'm' is attached to rotating shaft at a radius are then the centrifugal force exerted by mass 'M' on the shaft is

F_c = Mw2R Where,

W = Angular velocity of shaft

R = Distance of CG from axis of rotation

M = Mass attached to shaft.



Three masses 10 kg, 20 kg and 15kg are attached at a point ....

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