
Subject Code

- Any - ▼

Chapter Name

- Any - ▼

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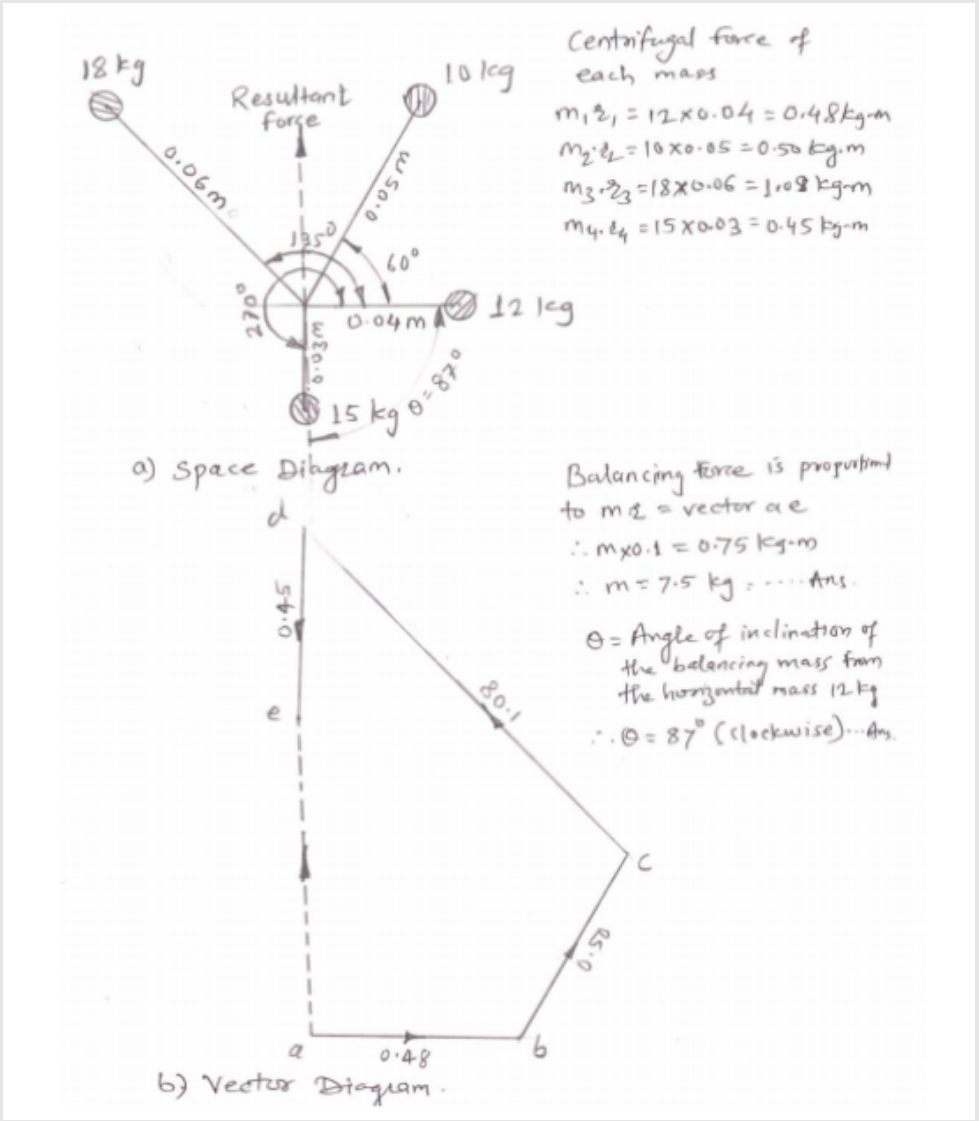
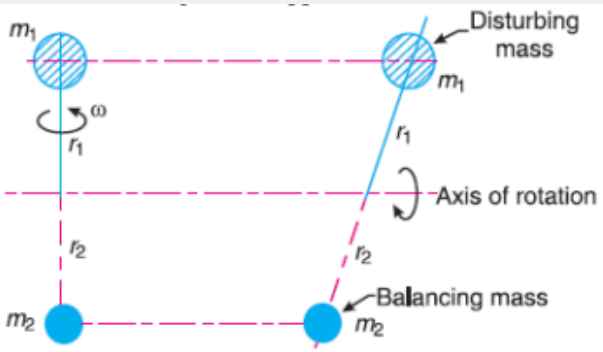
Examination: 2017 SUMMER

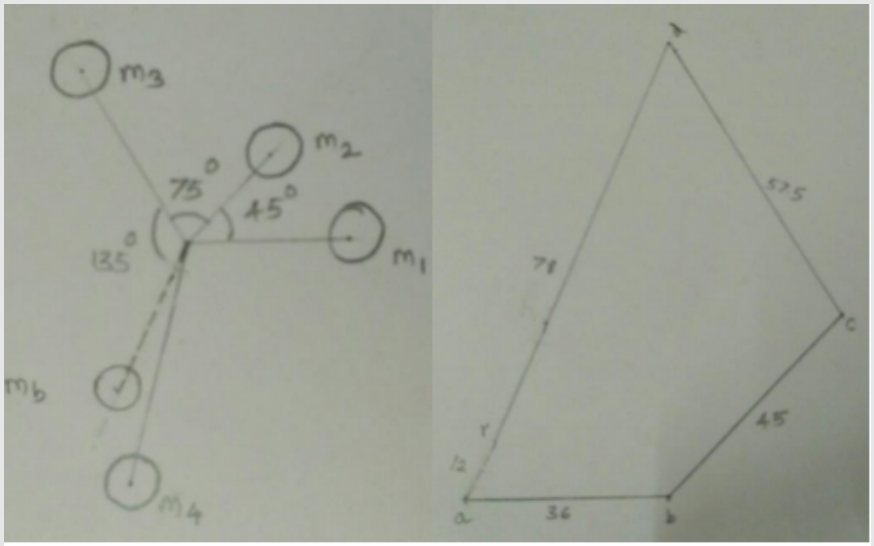
Que.No	Marks	
Q 1 o)	2	Question: **State effects of imbalance in machine.** Answer: **Effects of imbalance in machine** 1. Imbalance imparts vibratory motion to the frame of the machine. 2. Produces noise which leads to human discomfort. 3. Detrimental effects on the machine performance & structural integrity of the machine foundation. ----------

Que.No	Marks	
Q 6 e)	4	Question: **State reasons for balancing of rotating elements of machine. Explain balancing concept.** Answer: **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. **Concept of balancing:** When a mass moves in circular pitch, it experience a centripetal acceleration which generates a force acting towards the center of rotation. An equal and opposite force which is acting radially outwards which is called centrifugal force. This force is the disturbing force for the system. The magnitude of this force remains constant but the direction goes on changing with the rotation of mass. The centrifugal force , on a rotating machine can be expressed mathematically as follows: **$Fc = m. \omega^2.r$ Newton** Where, m = Mass of rotating part in kg, Ω = angular speed of this part in rad/sec, and r = Distance of the center of gravity of mass from the axis of rotation of part in m. For the balance of rotating masses, it is the centrifugal force which is to be balanced. This type of problem is very common in steam turbine rotors, engine crank shafts, rotory compressors and centrifugal pumps. ----------

Que.No	Marks	
Q 6 f)	4	Question: **Four masses A, B, C and D are attached to a shaft and revolve in the same plane. The masses are 12 kg, 10 kg, 18 kg and 15 kg respectively and their radii of rotations are 40 mm, 50 mm, 60 mm and 30 mm. The angular position of the masses B, C and D are 60O, 135O ,and 270O from the mass 'A'. Find the magnitude and position of the balancing mass at a radius of 100 mm. Use graphical method only.** Answer:  ----------

Examination: 2017 WINTER

Que.No	Marks	
Q 1a)(h)	2	Question: **Why is balancing of rotating parts necessary for high speed engines ?** Answer: 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. ----------
Q 3 e)	4	Question: **Write the procedure for balancing of a single rotating mass by single masses rotating in the same plane.** Answer: 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. In order to counteract the effect of this force, a balancing mass (m2) may be attached in the same plane of rotation as that of disturbing mass (m1) 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). ∴ Centrifugal force due to mass m_2, $F_{C2} = m_2 \cdot \omega^2 \cdot r_2$ . . . (*ii*) Equating equations (*i*) and (*ii*), $m_1.\omega^2 \cdot r_1 = m_2 \cdot \omega^2 \cdot r_2$ or $m_1 \cdot r_1 = m_2 \cdot r_2$ ----------

Que.No	Marks	
Q 4 f)	4	Question: **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 the position and magnitude of the balance mass required, it its radius of rotation is 0.2 m. The masses revolve in same plane.** Answer: 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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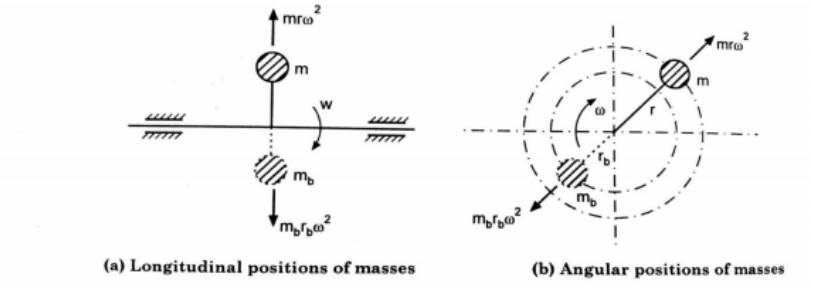
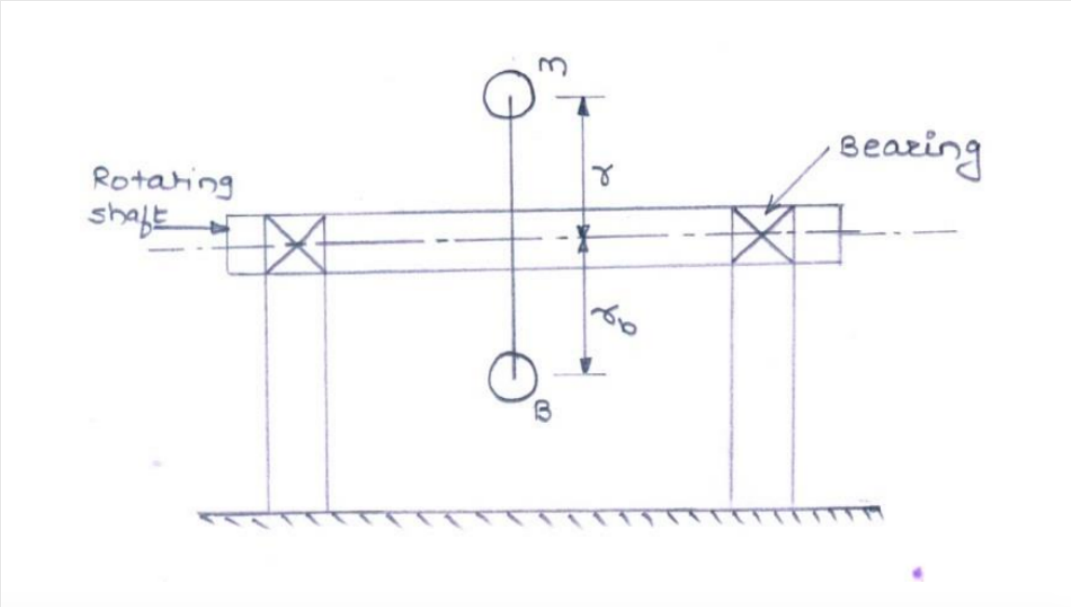
Que.No	Marks	
Q 1a)(viii)	2	Question: **Why is balancing of rotating parts necessary for high speed engines?** Answer: The high speed of engines and other machines is a common phenomenon now-a-days. It is, therefore, very essential that all the rotating and reciprocating parts should be completely balanced as far as possible. If these parts are not properly balanced, the dynamic forces are set up. These forces not only increase the loads on bearings and stresses in the various members, but also produce unpleasant and even dangerous vibrations. The balancing of unbalanced forces is caused by rotating masses, in order to minimize pressure on the main bearings when an engine is running. ----------
Q 3 e)	4	Question: **Write the procedure of balancing single rotating mass when it balance mass is rotating in the same plane as that of disturbing mass.** Answer:  (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 'mrω² '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] ----------

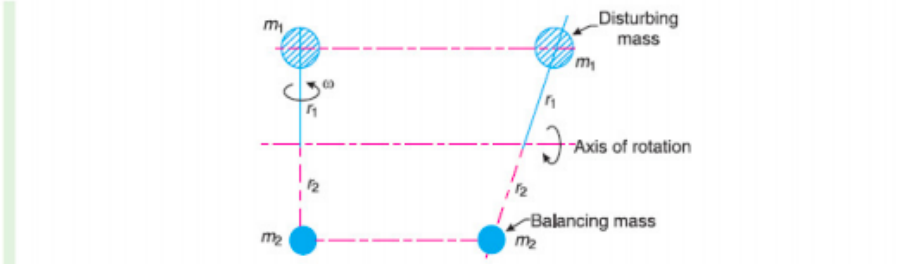
Que.No	Marks	
Q 4 f)	4	Question: **A rotor having the following properties : m1 = 4 kg r1 = 75 mm θ1 = 45o m2 = 3 kg r2 = 85 mm θ2 = 135o m3 = 2.5 kg r3 = 50 mm θ3 = 240o Determine the amount of the countermass at a radial distance of 75 mm required for the static balance.** Answer: **Data :** m1= 4 kg r1= 75 mm θ1 = 45° m1r1= 300 kg-mm m2= 3kg r2= 85 mm θ2 = 135° m2r2 = 265 kg-mm m3= 2.5 kg r3= 50 mm θ3 = 240° m3r3 = 125 kg-mm Radius of balance mass = r = 75 mm Let m=Balancing mass Resolving horizontally, $\sum H = m1r1cos\theta1 + m2r2cos\theta2 + m3r3cos\theta3$ = 300cos 45°+265 cos 135° +125 cos 240° = -37.87 kg-mm [1 M] Resolving vertically, $\sum V = m1r1sin\theta1 + m2r2sin\theta2 + m3r3sin\theta3$ = 300sin 45°+265 sin 135° +125 sin240° 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] ----------

Examination: 2016 WINTER

Que.No	Marks	
Q 1a)(viii)	2	Question: **State the adverse effect of imbalance of rotating elements of machine.** Answer: **Adverse effect of imbalance of rotating elements:** a) Vibration, noise and discomfort, b) Machine accuracy get disturbed, c) Power losses, d) More maintenance ----------
Q 3 d)	4	Question: **Three masses 10 kg, 20 kg and 15kg are attached at a point at radii of 20 cm, 25cm and 15 cm respectively. If the angle between successive masses is 60° and 90°. Determine analytically the balancing mass to be attached at radius of 30cm.** Answer: ----------

Que.No	Marks	
Q 4 f)	4	Question: **Explain the process of balancing of single rotating mass by a single mass rotating in the same plane.** Answer: 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.  Due to continuous rotation of shaft the centrifugal force developed will be continuously changing its direction. It will cause bending moment on shaft. To counter act the effect of centrifugal force the balance weight may be introduced in same plane of rotation. This balance weight should be attached it will result in exactly equal but opposite centrifugal force to that of disturbing weight 'M'. The balanced centrifugal force is given by F_b = mbw2Rb For balancing the shaft – $Mw^2R = mbw^2R_b$. ----------

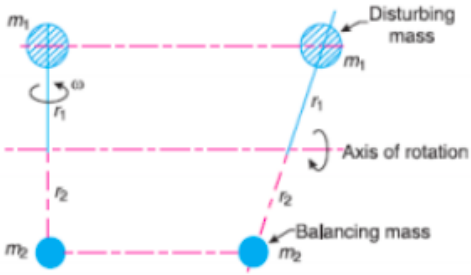
Examination: 2015 SUMMER

Que.No	Marks	
Q 1a)(h)	2	Question: **Why is balancing of rotating parts necessary for high speed engines ?** Answer: **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. These forces not only increase the loads on bearings and stresses in the various members, but also produce unpleasant and even dangerous vibrations. The balancing of unbalanced forces is caused by rotating masses, in order to minimize pressure on the main bearings when an engine is running. ---
Q 3 c)	4	Question: **Write the procedure for balancing of a single rotating mass by single masses rotating in the same plane.** Answer: 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*), $$m_1 \cdot \omega^2 \cdot r_1 = m_2 \cdot \omega^2 \cdot r_2 \quad \text{or} \quad m_1 \cdot r_1 = m_2 \cdot r_2$$ ---

Que.No	Marks	
Q 4 e)	4	Question: **Three masses 10 kg, 20 kg and 15 kg are attached at a point at radii of 20 cm, 25 cm and 15 cm respectively. If the angle between successive masses is 60° and 90°. Determine analytically the balancing mass to be attached at radius of 30 cm.** Answer: 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, $\Sigma H = m_1 \cdot r_1 \cos\theta_1 + m_2 \cdot r_2 \cos\theta_2 + m_3 \cdot r_3 \cos\theta_3$ $= 2 \cos 0° + 5 \cos 60° + 2.25 \cos 150°$ $=$ 2.55 kg-m Now resolving vertically, $\Sigma V = m_1 \cdot r_1 \sin\theta_1 + m_2 \cdot r_2 \sin\theta_2 + m_3 \cdot r_3 \sin\theta_3$ $= 2 \sin 0° + 5 \sin 60° + 2.25 \sin 150°$ $=$ 5.455 kg-m $\therefore$ Resultant, $R = \sqrt{(\Sigma H)^2 + (\Sigma V)^2}$ = 6.02 kg-m We know that $m \cdot r = R = 6.02$ m = 6.02 / 0.30 = 20.067 kg and $\tan\theta' = \Sigma V / \Sigma H$ = θ' = 64.94°

Examination: 2015 WINTER

Que.No	Marks	
Q 1a)(viii)	2	Question: **State any two adverse effects of imbalance.** Answer: 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. These forces increase the loads on bearings and stresses in the various members. Also produce unpleasant and even dangerous vibrations.

Que.No	Marks	
Q 3 e)	4	Question: **State the procedure of balancing single rotating mass when its balancing mass is rotating in the same plane as that of disturbing mass.** Answer: 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.  Fig. 21.1. 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*), $$m_1 \cdot \omega^2 \cdot r_1 = m_2 \cdot \omega^2 \cdot r_2 \quad \text{or} \quad m_1 \cdot r_1 = m_2 \cdot r_2$$ ----------

Que.No	Marks	
Q 4 f)	4	Question: **Four masses m1, m2, m3 and m4 are 200 kg, 300 kg, 240 kg, and 260 kg respectively. The corresponding radii of rotation are 0.2 m, 0.15 m, 0.25 m and 0.3 m respectively and the angles between successive masses are 45°, 75° and 135°. Find the position and magnitude of balance mass required, if its radius of rotation is 0.2 m.** Answer:

Given : $m_1 = 200$ kg ; $m_2 = 300$ kg ; $m_3 = 240$ 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 ; $\theta_1 = 0°$; $\theta_2 = 45°$; $\theta_3 = 45° + 75° = 120°$; $\theta_4 = 45° + 75° + 135° = 255°$; $r = 0.2$ m

Let m = Balancing mass, and

θ = The angle which the balancing mass makes with m_1.

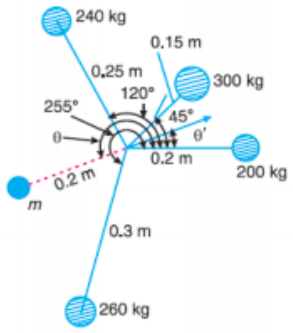
Since the magnitude of centrifugal forces are proportional to the product of each mass and its radius, therefore

$$m_1 \cdot r_1 = 200 \times 0.2 = 40 \text{ kg-m}$$

$$m_2 \cdot r_2 = 300 \times 0.15 = 45 \text{ kg-m}$$

$$m_3 \cdot r_3 = 240 \times 0.25 = 60 \text{ kg-m}$$

$$m_4 \cdot r_4 = 260 \times 0.3 = 78 \text{ kg-m}$$



The problem may, now, be solved either analytically or graphically. But we shall solve the problem by both the methods one by one.

Analytical method

The space diagram is shown in Fig.

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

$$\Sigma H = m_1 \cdot r_1 \cos\theta_1 + m_2 \cdot r_2 \cos\theta_2 + m_3 \cdot r_3 \cos\theta_3 + m_4 \cdot r_4 \cos\theta_4$$

$$= 40\cos 0° + 45\cos 45° + 60\cos 120° + 78\cos 255°$$

$$= 40 + 31.8 - 30 - 20.2 = 21.6 \text{ kg-m}$$

Now resolving vertically,

$$\Sigma V = m_1 \cdot r_1 \sin\theta_1 + m_2 \cdot r_2 \sin\theta_2 + m_3 \cdot r_3 \sin\theta_3 + m_4 \cdot r_4 \sin\theta_4$$

$$= 40\sin 0° + 45\sin 45° + 60\sin 120° + 78\sin 255°$$

$$= 0 + 31.8 + 52 - 75.3 = 8.5 \text{ kg-m}$$

$\therefore$ Resultant, $R = \sqrt{(\Sigma H)^2 + (\Sigma V)^2} = \sqrt{(21.6)^2 + (8.5)^2} = 23.2$ kg-m

We know that $m \cdot r = R = 23.2$ or

Balancing mass $m = 23.2 / r = 23.2 / 0.2 = 116$ kg **Ans.**

and $\tan\theta' = \Sigma V / \Sigma H = 8.5 / 21.6 = 0.3935$ or $\theta' = 21.48°$

Since θ' is the angle of the resultant R from the horizontal mass of 200 kg, therefore the angle of the balancing mass from the horizontal mass of 200 kg,

$$\theta = 180° + 21.48° = 201.48° \text{ Ans.}$$
