**Lecture Fourteen**

**4. Balancing of Several Masses Rotating in Different Planes**

Let us consider four masses *m*1, *m*2, *m*3 and *m*4 revolving in planes 1, 2, 3 and 4

respectively as shown in Fig. 5(*a*). The relative angular positions of these masses





**Fig. 5.** Balancing of several masses rotating in different planes.

are shown in Fig. 5(*b*). The magnitude of the balancing masses *m*A and *m*B in planes *A* and *B* may be obtained as discussed below:

**1.** Take one of the planes, say *A* as the reference plane (*R.P*.).

**2.** Tabulate the data as shown in Table: 2.

**3.** The couples about the reference plane must balance, *i.e*. the resultant couple

must be zero.

**4.** The forces in the reference plane must balance, *i.e.* the resultant force must be zero.

Where *n*: number of masses

**Table ( 9)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Plane** | **Mass (m)** | **Radius (r)** | **Angle (Ө)** | **Centrifugal force ÷ω2**  **(m.r)** | **Distance from plane A** | **Couple ÷ω2**  **m.r.l.** |
| **1** | **m1** | **r1** | **Ө1** | **m1.r1** | **-l1** | **-m1.r1.l1** |
| **A(R.P.)** | **mA** | **rA** | **ӨA** | **mA.rA** | **lA** | **mA.rA.lA** |
| **2** | **m2** | **r2** | **Ө2** | **m2.r2** | **l2** | **m2.r2.l2** |
| **3** | **m3** | **r3** | **Ө3** | **m3.r3** | **l3** | **m3.r3.l3** |
| **B** | **mB** | **rB** | **ӨB** | **mB.rB** | **lB** | **mB.rB.lB** |
| **4** | **m4** | **r4** | **Ө4** | **m4.r4** | **l4** | **m4.r4.l4** |

**Graphical Representation**

**1.** Draw moment polygon (assuming that the moment direction is toward the centrifugal force) as shown in Fig .5(*c)*.

**2.** Draw force polygon as shown in Fig .5(*d)*.

**Example: 1**

Four masses *m*1, *m*2, *m*3 and *m*4 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 the balance mass required, if its radius of

rotation is 0.2 m.

**Solution:**

Let *m* = Balancing mass, and

θ = The angle which the balancing mass makes with *m*1*.*

1. **Analytical method**

Σ*H* =

Σ*H* = 40 cos0 + 45 cos45 + 60 cos120 + 78 cos255 = 21.63 kg.m



|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No. of masses** | **Mass (m)** | **Radius (m)** | **Angle (Ө)** | **Centrifugal force ÷ω2**  **(m.r)** |
| **1** | **200** | **0.2** | **0** | **0** |
| **2** | **300** | **0.15** | **45** | **45** |
| **3** | **240** | **0.25** | **120** | **60** |
| **4** | **260** | **0.3** | **225** | **78** |
| **5** | **m** | **0.2** | **Ө** | **m.r** |

Σ*V* =

Σ*V* = 40 sin0 + 45 sin45 + 60 sin120 + 78 sin255 = 8.43 kg.m

*F*C = (2163.2 )2 + (843.9)2 ]^.5 = 23.21 kg.m

*F*C = *m.r*, 23.21 = 0.2 × *m*  *m =* 116 kg **A**ns.

*tanӨ=* =

= 21.3

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,

θ = 180° + 21.48° = 201.48° **Ans.**

**2. Graphical method**

***Scale:*** let 10 kg.m = 1cm in paper.

Draw force polygon as shown in Fig .(*b)*.