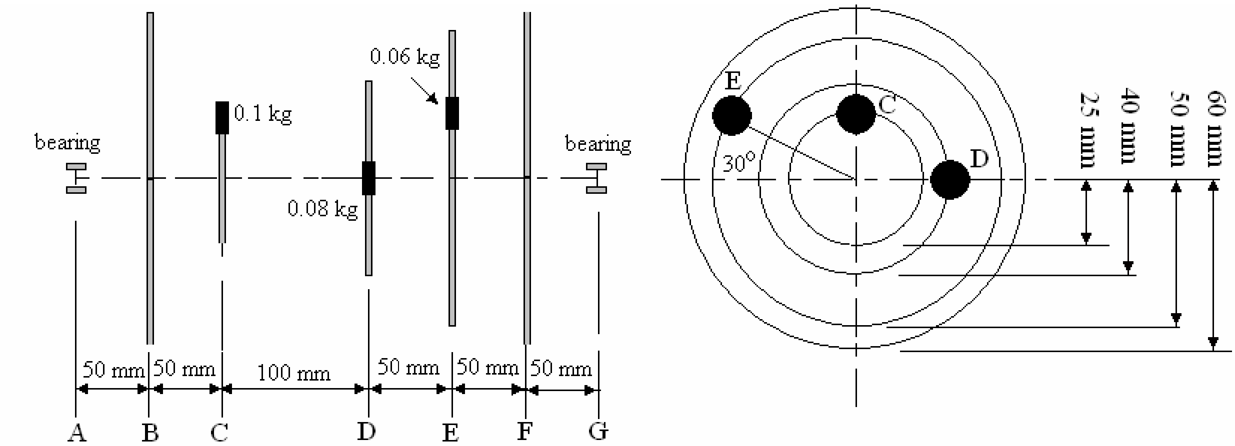
Dynamics of Mechanical Systems Q2 2000

The rigid rotor shown from a machine has unbalanced masses on disks C, D and E as indicated. Discs B and F are to be used for balancing. The shaft rotates at 1000 rev/min.

(i) Calculate the rotating forces on the bearings before balancing.

(ii) Determine the masses and their angular position that must be placed on B and F at a radius of 60 mm in order to produce complete balance.



SOLUTION

Angular velocity $\omega = 2\pi N/60 = 2\pi (2000)/60 = 209.4$ rad/s

(i)

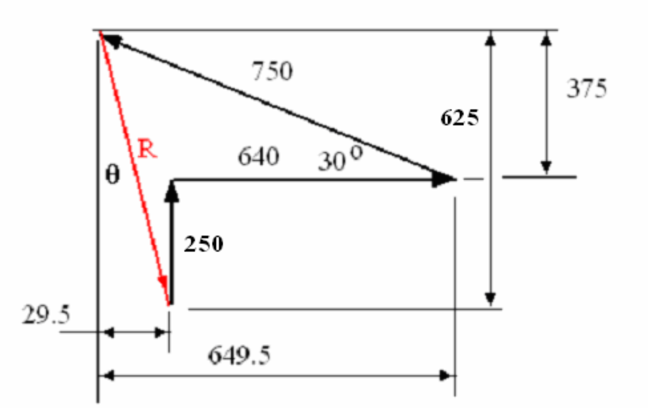
Use the tabular method. Make A the reference plane. X is measured from B

Remember centrifugal force = $M \omega^2 r$ and the moment about the ref plane is $M \omega^2 r x$

First find the out of balance moment.

Plane	Mass	Radius	x	Mr	Mrx
C	0.1	25	100	2.5	250
D	0.08	40	200	3.2	640
E	0.06	50	250	3.0	750

These are vectors and we must find the resultant Mrx vector. Draw vector diagram and produce the resultant as shown.

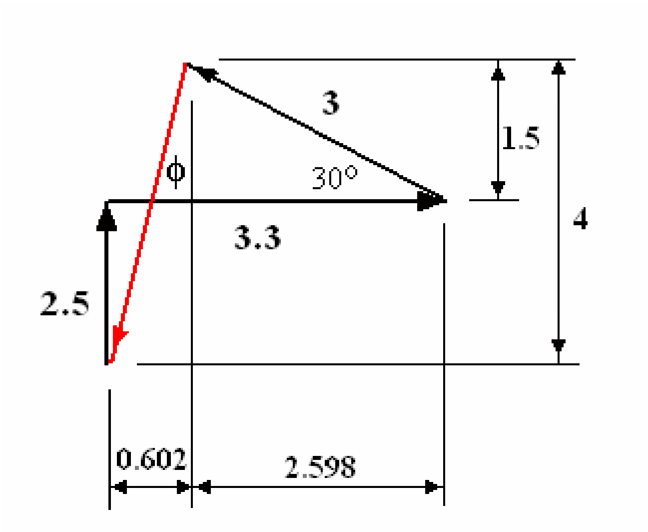


$R = (29.5^2 + 625^2)^{1/2} = 625.7$ kg mm^2 $\theta = \tan^{-1}(29.5/625) = 2.7^o$

The out of balance moment is $\omega^2 \times 625.7 \times 10^{-6} = 209.4^2 \times 625.7 \times 10^{-6} = 27.44$ N m based on plane A.

The force on bearing G that produces an equal and opposite couple is 27.44/0.35 = 78.4 N

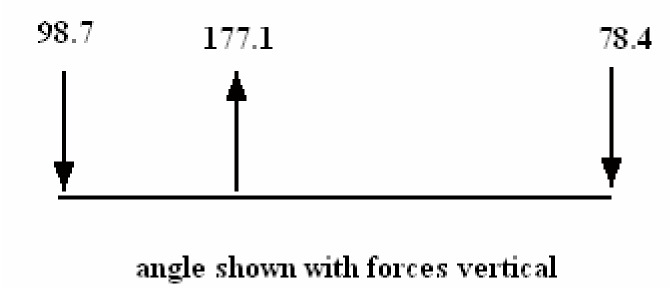
We need the resultant force so we must draw the MR polygon.



The total Mr is $(0.602^2 + 4^2)^{1/2} = 4.04$ kg mm.

The out of balance force $F = 4.04 \times 10^{-3} \times 209.4^2 = 177.1$ N

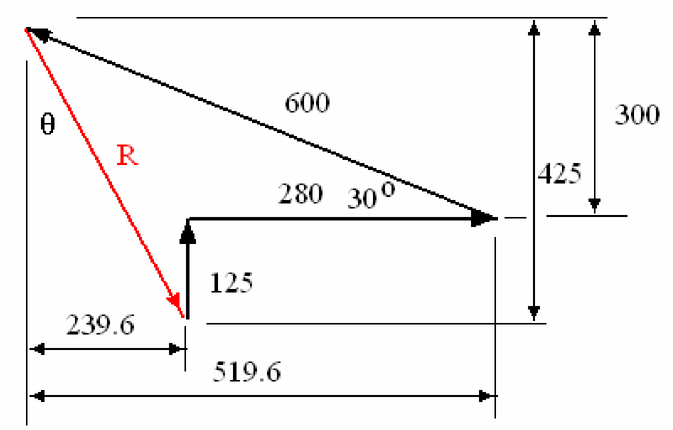
The force on bearing A is 177.1 - 78.4 = 98.7 N in the same direction.



(ii) Take B as the reference plane

Plane	Mass	Radius	x	Mr	Mrx
B	M_B	60	0	$60M_B$	0
C	0.1	25	50	2.5	125
D	0.08	40	150	3.2	480
E	0.06	50	200	3.0	600
F	M_F	60	250	$60M_F$	$15000\ M_F$

Draw the MRx vector diagram.

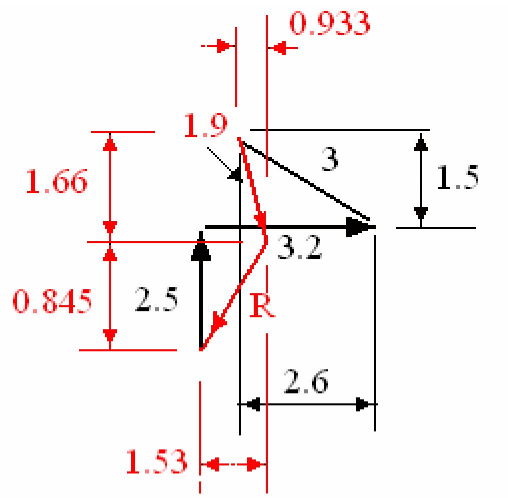


For complete balance R must be the MRx value for the mass on disk F.

$R = (239.6^2 + 425^2)^{1/2} = 487.9\ \text{kg mm}^2$ $\qquad \theta = \tan^{-1}(239.6/425) = 29.4^\circ$

It follows that for complete balance $15000\ M_F = 487.9\ \text{kg mm}^2$
$M_F = 487.9/15000 = 0.0325\ \text{kg}$

Now draw the MR vectors. Evaluate $60\ M_F = 1.952$



$R = (1.53^2 + 0.845^2)^{1/2} = 1.75\ \text{kg mm}$
This represents the disc B so $60\ M_B = 1.75\ \text{kg mm}$

$M_B = 0.0292\ \text{kg}$

The angle for mass B is $\tan^{-1}(1.53/0.845) = 61^\circ$ left of vertical down.