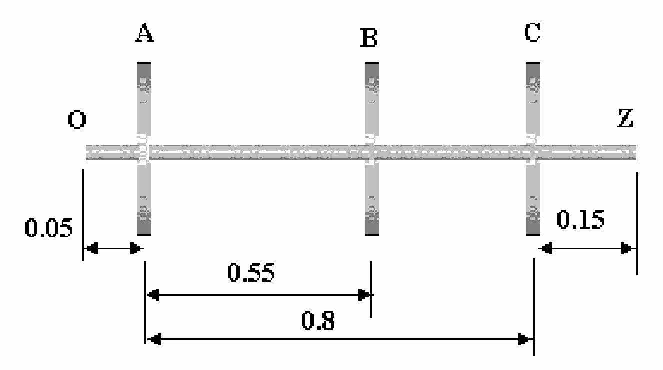
D225 DYNAMICS OF MECHANICAL SYSTEMS Q1

A rigid rotor caries three thin discs A, B and C mounted on a shaft 1 metre long running from O to Z. The distances from O are designated x in the table and the out of balance moment as MR in gramme metre. The out of balance force is at angle θ degrees.



(a) Calculate correcting forces needed on planes A and C to bring the system into balance.

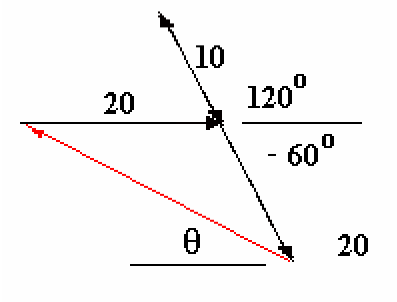
(b) The rotor is suspended from a bearing at O with the other end unrestrained. It can only be balanced on disc C. Calculate the corrective balance needed to ensure that end Z does not move. Calculate the magnitude of the force resulting at O when the shaft revolves at 500 rad/s.

	x (m)	MR (g m)	θ (degrees)
A	0.05	20	0
B	0.6	10	120
C	0.85	20	-60

SOLUTION

Make A the reference plane and re-tabulate as follows.

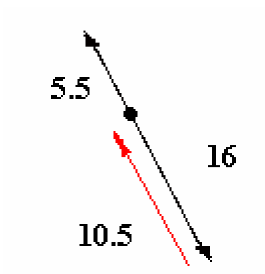
	x (m)	MR (g m)	θ (degrees)	MRx (g m^2)
A	0.0	20	0	0
B	0.55	10	120	5.5
C	0.8	20	-60	16



Construct the MR polygon.

The red vector produces balance and may be calculated or measured. The length is 26.5 g m and the angle θ is 19.1^o. This is placed on plane A. The table may be further completed.

	x (m)	MR (g m)	θ (degrees)	MRx (g m^2)
A	0.0	20	0	0
B	0.55	10	120	5.5
C	0.8	20	-60	16
A2	0.0	26.5	160.9	0



Next construct the MRx polygon. This is simply two vectors at opposite angles giving a closing vector of 10.5 at 120^o.

This is to be placed on C so the value of MR is 10.5/0.8 = 13.125 g m

This now produces an imbalance of 13.125 on the static balance (MR) so an equal and opposite force is added to A

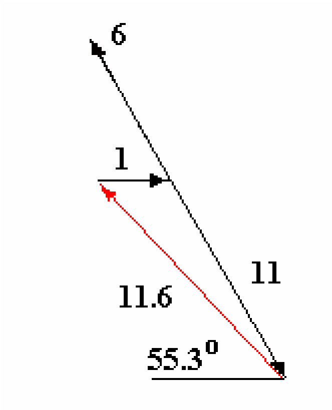
The complete table is

	x (m)	MR (g m)	θ (degrees)	MRx (g m^2)
A	0.0	20	0	0
B	0.55	10	120	5.5
C	0.8	20	-60	16
A2	0.0	26.5	-199.9	0
A3	0.0	13.125	-60	0
C2	0.8	13.125	120	10.5

A2 and A3 can be combined to a single MR value of 18.5 at 187 degrees. The final table is

(b) The key here is that the moment about end O must be zero to stop the other end moving and static balance must be ignored. Make O the reference plane and re-tabulate as follows with x measured from O

	x (m)	MR (g m)	θ (degrees)	MRx (g m^2)
A	0.05	20	0	1
B	0.6	10	120	6
C	0.85	20	-60	17

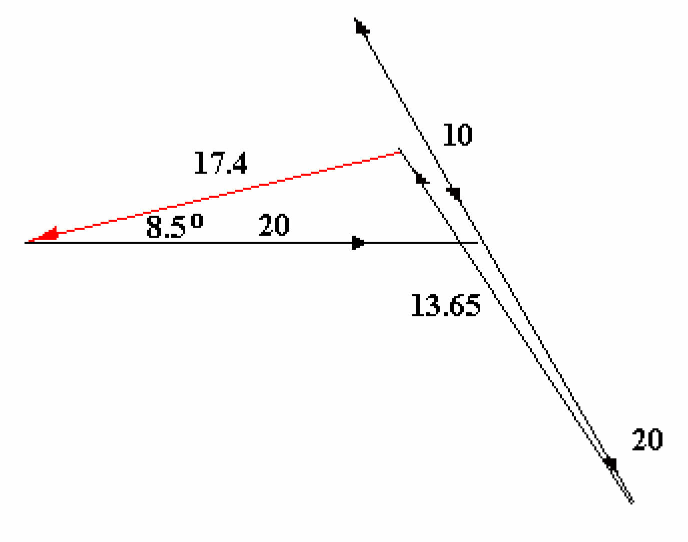


Construct the MR polygon. The closing vector is 11.6 at 124.7°

This produces zero moment about end O and the balance needed on C is 11.6/0.85 = 13.65 g m at 124.7°

There is now a static imbalance that may be found from the MR polygon.

	x (m)	MR (g m)	θ (degrees)	MRx (g m^2)
A	0.05	20	0	1
B	0.6	10	120	6
C	0.85	20	-60	17
C2	0.85	13.65	124.7	11.6



A static imbalance of 17.4 g m at 188.5° now exists and this will be countered by a force in the bearing at O. Centrifugal force = $m\omega^2R$ so the force on the bearing is MR x ω^2 = 17.4 x 10^{-3} (kg m) x 500^2 = 4350 N

Note there are various methods of solving the vector diagrams such as drawing to scale or calculating the vertical and horizontal components of each vector and summing them to find the resultant.