SECTION C: STATICS AND DYNAMICS

Q7 A rotating shaft has six masses A, B, C, D, E, and F attached to it, with centres of mass lying at radii at 70, 100, 110, 90, 175 and 180mm respectively. The planes in which the masses rotate are spaced, A to B 0.5m, B to C 0.7m, C to D 0.7m, D to E 0.6m, E to F 0.5m the masses of A, B, C, E, and F are 20, 19,
21, 17 and 18 kg respectively. The relative position of B from A is 60 degrees, and C from A is 120 degrees. Find the value of D and the relative angular settings for the shaft to be in complete balance. **(20 Marks)**

Q8 You are a suspensions expert with a motor rally team. Your suspension employs close coiled helical springs. At rest the load on each spring is 4kN. The maximum estimated load on each spring due to pothole forces is 50kN. The maximum allowable change in compression of each spring, from rest to maximum load, is 9 cm. Determine the wire diameter of each spring and the maximum shear stress given, the coil diameter is 16cm, there are 8 coils, ($G = 350{,}000\ N/mm^2$). If a different spring material was employed ($G=500{,}000\ N/mm^2$) and 6 coils employed what would the new coil diameter be with the same wire diameter. Assuming both materials have a density of 40kN/m^3, what would the net change in mass between the two springs? **(20 Marks)**

Q9 A heavy-duty compressor weighing 230kg operates at 3500 rpm. The rotating parts are well balanced. If the reciprocating parts produce a harmonic force function of $F = 3750\cos\omega t$ in kN, and the damper for the engine mounting introduces a damping factor $\zeta=0.45$.

(i) Determine the natural frequency of vibration of the system and specify the spring stiffness for the engine mounting such that only 2% of the resultant force is transmitted to the foundation.

(ii) Determine the magnitude of the transmitted force if the natural frequency of vibration of the system is doubled. **(20 Marks)**

END OF SECTION C

FIGURES Q1, Q2, Q3, Q4, and Q5 Follow.

Q8 You have been commissioned to design the suspension for a new sports utility vehicle (SUV). The net weight of the SUV is 3500kg, distributed 45% on the rear axle and 55% on the front axle. When fully loaded, an additional 1000kg are added to the SUV, distributed 60% on the rear axle and 40% on the front axle. You are using, on the front axle2 identical helical close-coiled springs in parallel, and on the rear axle 2 identical leaf springs in parallel. Your design constraint is, completely unloaded to fully loaded, the maximum static deflection on either axle should not exceed 20cm.

Given for:

Helical spring:

Mean coiled diameter	= 30cm
Modulus of rigidity	= 83.5 GN/m^2
Wire diameter	= 35mm

Leaf spring:

Length	= 1m
Number of leaves	=8
Width to thickness ratio	= 8:1
Elastic modulus	= 125 GN/m^2

Find:

(a) The number of complete coils required in the helical springs [5 marks]

(b) The width of the leaf springs [5 marks]

(c) The deflection at both axles when acted upon the net weight of the pickup only. [5 marks]

(d) If the distance between the rear and front axle is 6m, what is the magnitude and direction of the shift in the centre of gravity of the pickup when loaded with additional 5000kg? [5 marks]

Q9 A hollow 1m shaft of outside radius 60mm, inside radius 55mm and density 7g/cm^3 carries 4 unbalanced masses as follows:

Masses A, B, C, and D are 10, 12, 14, and 16kg respectively, rotating at radii 16, 14, 12, and 10cm respectively, and spaced from one end of the shaft at 30, 45, 60, and 75 cm respectively. The angular spacing from A to B, C, and D are 90, 180 and 270 degrees respectively.

(a) Balance the shaft using two 10kg masses at either end [7 marks]

(b) If before balancing, the shaft rotated at 3000rpm, what will be its rotation after balancing? [6 marks]

(c) If all masses are removed from the shaft and the power transmitted is 165 kW, determine the maximum shear stress on the shaft [7 marks]

Note: uniform disc or cylinder, radius r, I about the central axis is $mr^2/2$ and $k = r/\sqrt{2}$

Question 7

You are designing the suspension for a new pick up. The net weight of the pick up is 900kg, distributed 35% on the rear axle and 65% on the front axle. When fully loaded an additional 1000kg is added to the pickup, distributed 70% on the rear axle and 30% on the front axle. You are using, on the front axle 2 identical helical close coiled springs in parallel, and on the rear axle 2 identical leaf springs in parallel. Your design constraint is, completely unloaded to fully loaded, the maximum static deflection on either axle should not exceed 8 cm. given for:

Helical spring:

Mean coiled diameter	=	15cm
Modulus of rigidity	=	82.5 GN/m^2
Wire diameter	=	20mm

Leaf spring:

Length	=	60cm
Number of leaves	=	3
Width to thickness ratio	=	12:1
Elastic modulus	=	120 GN/m^2

Find:

(a) the number of coils required in the helical springs ***(5 marks)***

(b) the width of the leaf springs ***(5 marks)***

(c) the deflection at both axles when acted upon the net weight of the pickup only. ***(4 marks)***

(d) If the distance between the rear and front axle is 2.4m what is the magnitude and direction of the shift in the centre gravity of the pickup when loaded with the additional 1000kg. ***(6 marks)***

Question 8

A solid 1m shaft of radius 30 mm and density 6 g/cm^3 carries 4 unbalanced masses spaced as follows:

Masses A, B, C, and D are 7, 8, 9, and 12kg respectively, rotating at radii 11, 9, 10, 12cm respectively, and spaced from one end of the shaft at 25, 40, 55, and 75 cm respectively. the angular spacing from A to B, C, and D are 70, 170, and 300° respectively.

(a) Balance the shaft using two 10 kg masses at either end ***(9 marks)***

(b) If before balancing, the shaft rotated at 300 rpm what will be its rotation after balancing. ***(5 marks)***

(c) If all masses are removed from the shaft and the power transmitted is 10 kW, determine the maximum shear stress on the shaft. ***(6 marks)***

Note: Uniform disc or cylinder, radius r. I about the central axis is $\frac{mr^2}{2}$ and

$$k = \frac{r}{\sqrt{2}}$$

Question 9

You are designing the spring damper system for a 850 kg motor rally vehicle. The test road is sinusodially undulated with a maximum displacement of 30cm. If the maximum allowable displacement of the vehicle relative to the road is 36cm, determine:

(a) the damping ratio and state whether it is over, critically or under damped ***(5 marks)***

If the length of one undulation is 4m, and the damping coefficient is 8000kg/s, determine:

(b) the stiffness of the suspension ***(4 marks)***

(c) the speed in km/h of the vehicle at maximum displacement ***(5 marks)***

(d) the maximum displacement of the vehicle if the and the vehicle is moving a 170km/h ***(6 marks)***

THE RELEVANT DIAGRAMS FIG Q3,FIG 4A,B & C,FIG 5 & 6 ARE ATTACHED

END OF EE392 EXAMINATION