Bachelor of Mechanical Engineering-Third Year, First Semester, 2024

Dynamics of Machines

Full Marks: 100 **Writing Time: 3.0 Hours**

Answer Any Five (5) Questions

[*Assume any missing data with proper justifications*]

Q1. Derive the differential equation of motion of the following system for small translational displacement of mass block at **A** and hence find the natural frequency of the system. **BCD** is a massless lever pivoted at **C**. Neglect the mass of all the links shown in the figure. If the damping coefficient *c* used in the system be given by: $\sqrt{\frac{mk}{5}}$, then calculate the ratio of the amplitudes of displacement of the mass at **two and half-cycle** apart from each other during free vibration of the system. **15+5=20**

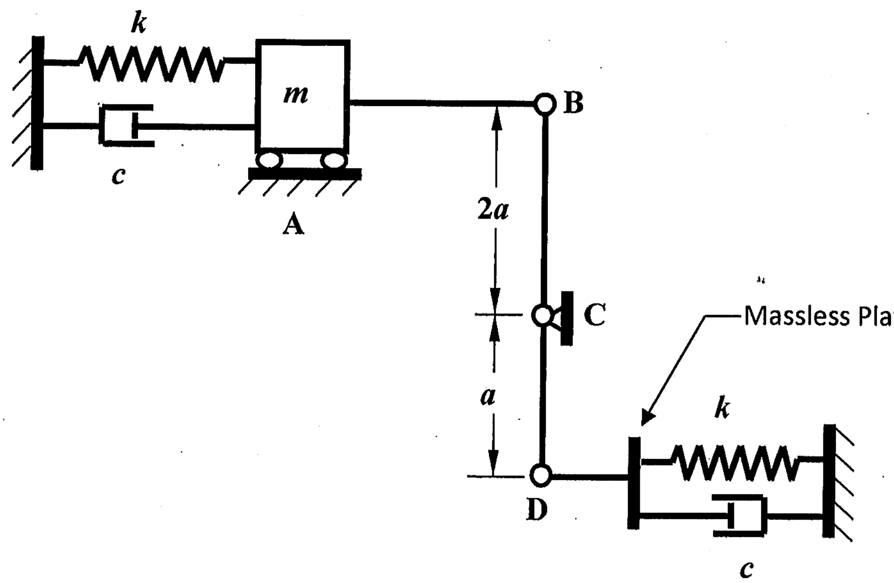


Fig Q1

Q2. Derive from the **first principles** the ratio of amplitudes of motion of mass and that of the support base as shown in the **Fig Q2**. Assume the support base of the system moves according to the equation $y = Y \sin \omega t$.

[Turn over

What should be the absolute displacement, x, **up or down**, of the mass block from its mean position at $t = \frac{2\pi}{\omega_n}$ seconds if the following data apply to the system:

m = **140 kg**, k = **50 N/mm** and ζ = Damping ratio=**0.25** for the support motion: $y = 10\sin\left(\frac{\omega_n t}{2}\right)$, ω_n being the undamped natural frequency of the system. **10+10=20**

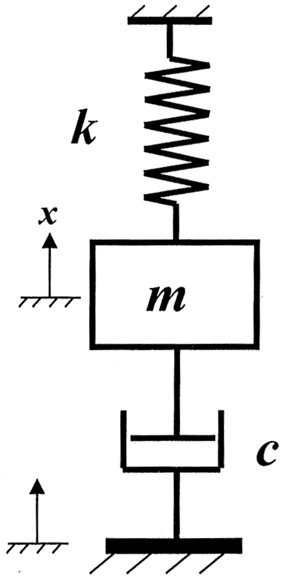


Fig Q2

Q3(a) A massless shaft of diameter **14 mm** and length **1200 mm** supported in **long bearings** carries a rotor disc of mass **16 kg** at its mid-span. Due to bad workmanship, the rotor is eccentrically mounted on the shaft with an eccentricity of **0.4 mm.** If the permissible stress developed in the shaft is limited to **70 MPa,** then calculate the **unsafe limits of speed of rotation** of the rotor-shaft system. Assume the Young's modulus of elasticity of the shaft material as **200 GPa.**

In case of a shaft supported in **long bearings,** its **static deflection** due to a load W at **mid-span** and the **maximum bending moment** may be assumed as $\frac{Wl^3}{192EI}$, $\frac{Wl}{8}$ respectively. Neglect any damping of the system. **15**

(b) Explain briefly with the help of suitable graph the principles of **Vibration Isolation** and **Vibration Transmission.** **5**

Q4 Consider a **radial engine** with N number of cylinders. Find out the primary unbalance force.

How can the primary unbalance force be balanced? Explain with a figure.

What is the state of unbalance for a higher harmonic **$2k$**, where k=1, 2, 3...

Consider a radial engine with **7 cylinders**. Show whether 8th and 10th harmonics are balanced.

[You may use the following relations:-

$$\cos(\theta) + \cos(\theta + \alpha) + \cos(\theta + 2\alpha) + \cdots. + \cos(\theta + \overline{n-1}\alpha) = \frac{\sin\frac{n\alpha}{2}}{\sin\frac{\alpha}{2}} \cos(\theta + \frac{n-1}{2}\alpha)$$

$$\sin(\theta) + \sin(\theta + \alpha) + \sin(\theta + 2\alpha) + \cdots. + \sin(\theta + \overline{n-1}\alpha) = \frac{\sin\frac{n\alpha}{2}}{\sin\frac{\alpha}{2}} \sin(\theta + \frac{n-1}{2}\alpha)$$

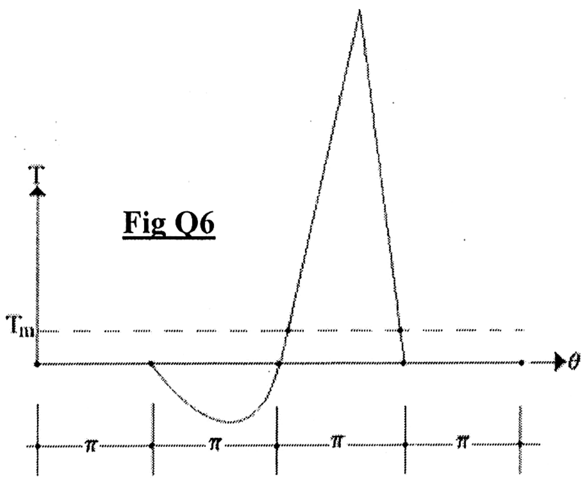
] **20**

Q5

For a twin cylinder **V engine**, derive the expressions for the total unbalance forces considering primary and secondary unbalances. Find out the expressions when V angle is **60^0**, **90^0** and **180^0**. What is the advantage when V angle is **90^0**? **20**

Q6

A single cylinder 4-stroke engine develops **25 hp** at **250 rpm**. The work done by the gases during the expansion stroke is **three times** the work done on the gases during the compression stroke. The work done during the suction and exhaust may be neglected. Determine the fluctuation of energy. If the flywheel weighs **1500 kg** and has a radius of gyration of **1.5m**, calculate the fluctuation of speed. Assume that the shape of the $T - \theta$ diagram is triangular during the expansion stroke. Refer to the following **FigQ6**. **20**



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