B.E. PRODUCTION ENGINEERING SECOND YEAR SECOND SEMESTER EXAMINATION-2025

MACHINE DYNAMICS

Time: Three Hours **Full Marks: 100**

Answer **ALL** questions.
All parts of a question (*a, b, c* etc) should be answered at one place.
Assume any missing data with proper justification.

1.a) Drawing an Aeroplane flying in a circular arc of **radius R**, identify the axes of spin, precession and gyroscopic couple.

b) Explain both the positive and negative aspects of gyroscopic couple, mentioning their different application areas.

c) For the turbine rotor of a ship, mass of **20 tonne**, radius of gyration of **75cm** and speed of **200 rpm** (clockwise when viewed from the Bow of the ship). The ship pitches harmonically with amplitude of **10°** and a time period of **20sec**. The turbine is supported on bearings **5m** apart. Estimate the maximum reaction at the front bearing and the direction of this reaction force when the front of the ship is rising. The *c.g.* (centre of gravity) of the rotor may be assumed to be at the midspan between the bearings.

5+3+12=20

2.a) Classify the governors according to their principles of functioning.

b) Discuss the working principle of a centrifugal governor with neat sketch.

c) A Porter governor has each arm **30cm** long. The upper arms are pivoted on the axis of rotation and the lower arms are attached to a sleeve at a distance of **4 cm** from the axis of rotation. The sleeve has a mass of **70 kg** and the each rotating ball has a mass of **10 kg**. Determine the range of speed when the radius of rotation of the balls is **20 cm** and the friction is equivalent to a load of **20 N** at the sleeve. Also, sketch the configuration of the system at this condition (one half).

3+5+12 = 20

3. A shaft carries three masses **B, C** and **D** of magnitude **30 Kg, 50 Kg** and **40 Kg** respectively and revolving at radii **240 mm, 120 mm** and **150 mm** in different respective planes. The planes containing masses **B** and **C** are **300 mm** apart. The angles between the cranks measured anticlockwise are **B** to **C 90°** and **B** to **D 220°**. Balancing mass is to be placed in plane **A**. If the balancing mass revolve at radius **180 mm**, find,

(i) The magnitude and angular position of mass **A**.
(ii) The position of planes **A** and **D**.

20

4. The turning moment curve for an engine is represented by the equation, **T = (20,000 + 9500 Sin2θ – 5700Cos 2θ) N-m.**, where **θ** is the angle moved by the crank from inner dead centre. If the resisting torque is constant, find:

(i) power developed by the engine ;

(ii) moment of Inertia of the flywheel in Kg-m^2, if the total fluctuation of speed is not to exceed **1%** of mean speed which is **180 rpm**;

(iii) angular acceleration of the flywheel when the crank has turned through **45^0** from inner dead centre.

20

5.a) A circular cylinder of mass **4 kg** and radius **150 mm** is connected by a spring of stiffness **4 kN/m** as shown in **Fig. 1**. It is free to roll on a horizontal rough surface without slipping. Determine the natural frequency.

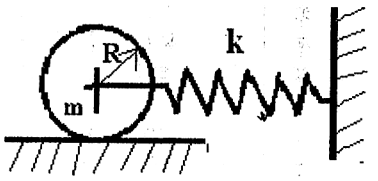

Fig. 1

b) Determine the **natural frequency** of the following vibrating systems when (i) mass is suspended at the bottom of **two springs in series** and (ii) mass is fixed **in between two springs**. Take stiffness of two springs as **5 N/m** and **8 N/m** and the mass suspended as **10 kg**.

10+10=20

6.a) A vibratory system in a vehicle is to be designed with the following parameters: **K= 100 N/m, C= 2 N-sec/m, m= 1kg**. Calculate:

(i) the decrease in amplitude from its starting value after **3 complete oscillations** and

(ii) the frequency of oscillation.

OR

Free damped vibration record of a **1000 kg** machine mounted on an isolator containing a spring and a dashpot, shows that in **4 cycles** the amplitude of oscillation diminishes from **5 mm** to **0.1 mm**. The time period between two successive peaks is **0.64 sec**. Determine the stiffness of the spring and the damping constant of the dashpot.

b) A machine weighing **4kN** is supported by springs of static deflection **8 mm**. A part of the machine rotating at the rate of **800 rpm** has a static unbalance of **3 gm**. Considering a damping ratio of **0.15**, determine:

i) amplitude of motion,

ii) transmissibility,

iii) transmitted force.

10+10=20

7.a) Discuss the conditions for a dynamically equivalent system in order to

determine the motion of a rigid link.

b) With a neat sketch derive an expression for the **crank effort** of a horizontal reciprocating engine. Neglect the mass of the connecting rod.

c) In the **toggle mechanism** as shown in **Fig. 2**, the crank **OA** rotates at **210 rpm counter-clockwise** increasing at the rate of **60 rad/s²**. For the given configuration, **determine** the **angular acceleration** of **link BD**.

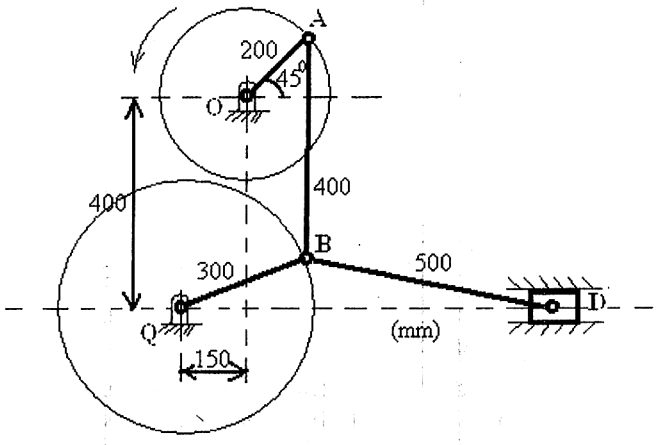

Fig. 2

5+5+10=20

8.a) State and prove the 'Kennedy's Theorem' of three instantaneous centres.

b) What is the instantaneous centre of rotation (centro) in kinematic of machines? Why it is important?

c) In a quick-return mechanism as shown in the **Fig. 3**, the crank rotates in anti-clockwise direction at **120 rpm**. The lengths of crank **AB** and the slotted arm **OC** are **150mm** and **700mm** respectively. The link **CD** is **200 mm** long. Determine the velocity and acceleration of the ram **D**.

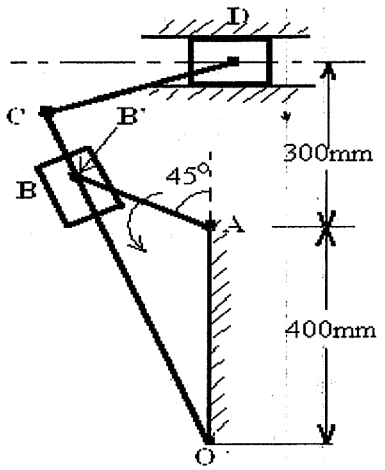

Fig. 3

5+(3+2)+10=20

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