B. E. PRODUCTION ENGG. 2ND YEAR 2ND SEMESTER EXAMINATION, 2019

MACHINE DYNAMICS

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

Answer **any FIVE** 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) Explain with neat sketch the motions: pitching, rolling and steering for a ship.

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

c) A ship has a rotor of mass **3 tonnes** rotating at **2500 rpm** and its radius of gyration is **30 cm**. If the rotation of the rotor is clockwise looking from the stern calculate the gyroscope couple that is set on the ship by rotor when

(i) the ship takes a left hand turn with a radius of **400m** at a speed of **50 km/h**,
(ii) pitching of the bow at an angular velocity of **2 rad/s** and
(iii) ship rolls due to the wave with a velocity of **0.1 rad/s**.

6+4+10=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 Proell governor has each arm **28.3 cm** long. The pivots of the upper and lower arms are **2 cm** from the axis. The central load acting on the sleeve has a mass of **30 kg** and the each rotating ball has a mass of **3.5 kg**. When the governor sleeve is in mid-position, the extension link of the lower arm is vertical and the radius of the path of rotation of the masses is **22 cm**. The vertical height of the governor is **20 cm** and the governor speed is **170 rpm**. Find (i) the **length** of the extension link, (ii) the **tension** in the upper arm and also sketch the system.

4+6+10 = 20

3. A shaft fitted with a flywheel rotates at **250 rpm** and drives a machine. The torque of machine varies in a cyclic manner over a period of **3 revolutions**. The torque rises from **750 N-m** to **3000 N-m** uniformly during **$^1/_2$ revolution** and remains constant for the following **revolution**. It then falls uniformly to **750 N-m** during the next **$^1/_2$ revolution** and remains constant for **one revolution**, the cycle being repeated thereafter. Determine the **power** required for driving the machine and the percentage fluctuation in speed, if the driving torque applied to the shaft is constant and the mass of the flywheel is **500 kg** with radius of gyration of **600 mm**.

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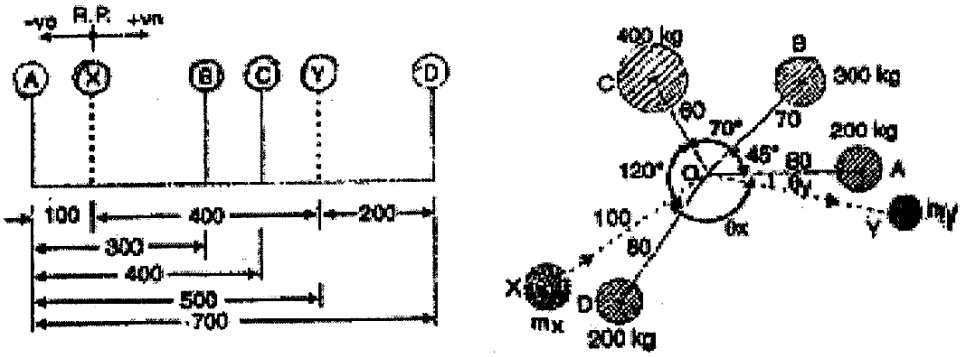
4. A shaft carries four masses **A, B, C and D (Fig. 1)** of magnitude **200 kg, 300 kg, 400 kg** and **200 kg** respectively and revolving at radii **80 mm, 70 mm, 60 mm** and **80 mm** in planes measured from A at **300 mm, 400 mm** and **700 mm**. The angles

between the cranks measured anticlockwise are A to B **45°,** B to C **70°** and C to D **120°**. The balancing masses are to be placed in planes X and Y. The distance between the planes A and X is **100 mm**, between X and Y is **400 mm** and between Y and D is **200 mm**. If the balancing masses revolve at a radius of **100 mm**, find their **magnitudes** and **angular** positions.



All dimensions in mm.

(a) Position of planes. (b) Angular position of masses.

Fig. 1

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5. Each crank of a four-cylinder vertical engine is **225 mm**. The reciprocating masses of the first, second and fourth cranks are **100 kg, 120 kg** and **100 kg** and the planes of rotation are **600 mm, 300 mm** and **300 mm** from plane of rotation of the third crank. Determine the **mass** of the reciprocating parts of third cylinder and the **relative angular** positions of the cranks if the engine is in complete primary balance.

20

6.a) **A** thin rectangular plate **having** mass 'M' **is** bent **into** semi-circular cylinder **of** radius 'R' **as shown in** Fig.2. **Determine its** period of oscillation **if it is allowed to** rock **on a** horizontal surface without slip.

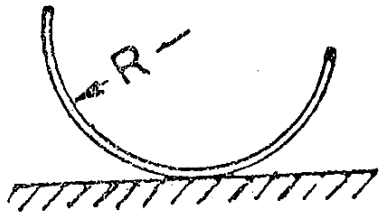

Fig. **2**

b) A **vibrating system** consisting of a weight of **25 N** and a spring of stiffness **2 kN/m** is viscously damped such that the ratio of any two consecutive amplitudes is **0.98**. Determine:

i) the **natural frequency** of the damped system,
ii) the **logarithmic decrement,**
iii) the **damping co-efficient**.

10+10=20

7.a) 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. m**. Considering a damping ratio of **0.15** , determine,

i) **amplitude** of motion,
ii) **transmissibility**,
iii) transmitted **force**.

b) 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.

10+10=20

8.a) Discuss the conditions for a dynamically equivalent system in order to determine the motion of a rigid link.

b) With a neat sketch explain the **thrust** on the sides of the cylinder walls of a horizontal reciprocating engine.

c) In the **toggle mechanism** as shown in **Fig. 3**, the crank **OA** rotates at **210 rpm counter-clockwise** increasing at the rate of **60 rad/s^2**. For the given configuration, **determine** the **angular acceleration** of **link BD**.

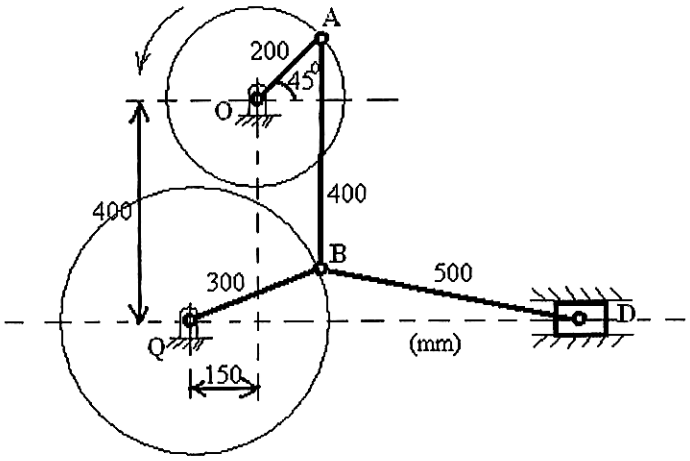

Fig. 3

5+5+10=20