

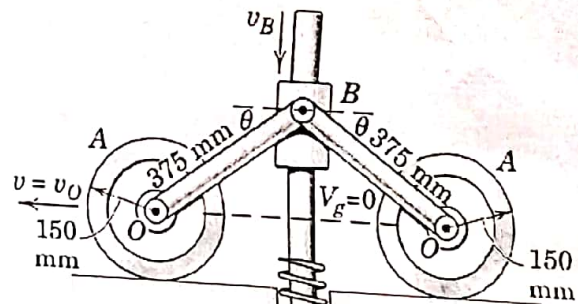
**DEPARTMENT OF APPLIED MECHANICS**  
**APL100: ENGINEERING MECHANICS (3-1-0)**  
**MAJOR TEST – I (Second Semester 2018-2019)**

**Part B: Maximum Marks: 64**

**8.25 A.M. to 10.00 A.M.**

**Note:** Show all the steps to get full credit. If you think something is missing, please assume the corresponding data. But do not forget to clearly mention your assumption/s.

**Q1** In the mechanism shown in Fig 1, each of the two wheels (radius 150 mm and radius of gyration 100 mm) has a mass of 30 kg. Each rigid link  $OB$  (length 375 mm) has a mass of 10 kg. The 7-kg collar at  $B$  slides on the fixed vertical shaft with negligible friction. The spring has a stiffness  $k = 30$  kN/m and is contacted (touched) by the bottom of the collar when the links reach the horizontal position. Friction is sufficient to prevent the wheels from slipping.

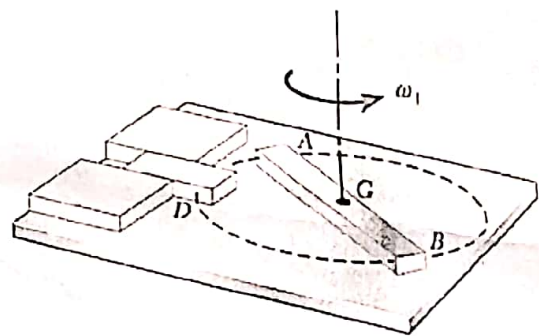


**Fig 1.**

If the collar is released from rest at the position  $\theta = 45^\circ$ , determine (a) the velocity  $v_B$  of the collar as it first strikes the spring and (b) the maximum deformation of the spring.

**08 Marks**

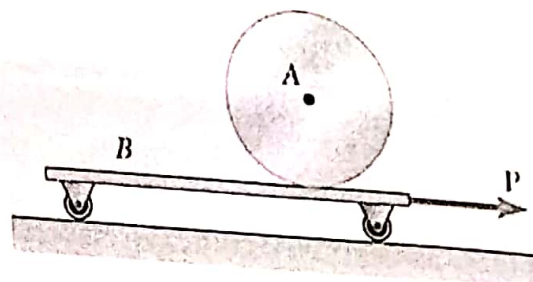
**Q2** A uniform slender bar  $AB$  of length  $L = 200$  mm and mass 0.5 kg is supported by a frictionless horizontal table in Fig 2. Initially the bar is spinning about its mass center  $G$  ( $G$  is not hinged with the plate) with a constant angular velocity  $\omega_1 = 6$  rad/s. Suddenly the latch  $D$  is moved to the right and is struck by end  $A$  of the bar. Knowing that the coefficient of restitution between  $A$  and  $D$  is  $e = 0.6$ , determine the angular velocity of the bar and the velocity of its mass center immediately after the impact.



**Fig 2**

**12 Marks**

**Q3** A 300-mm-radius cylinder of mass 8 kg rests on a 3-kg carriage as shown in Fig 3. The system is at rest when a force  $P$  of magnitude 20 N is applied. Knowing that the cylinder rolls without sliding on the carriage and neglecting the mass of the wheels of the carriage, determine (a) the acceleration of the carriage, (b) the acceleration of Point  $A$ , (c) the distance the cylinder has rolled with respect to the carriage after 0.5 s.

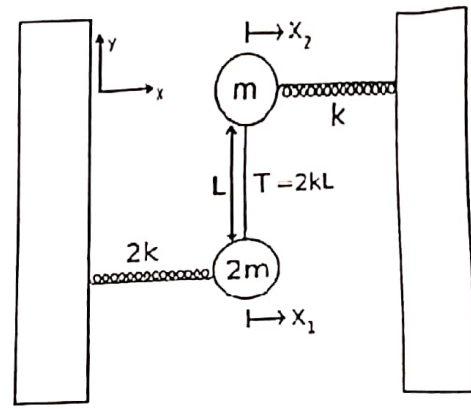


**Fig 3**

**12 Marks**

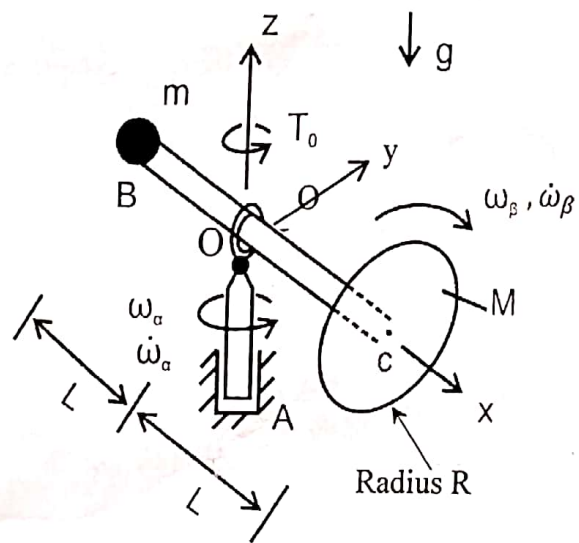
**Q4** The masses " $2m$ " and " $m$ " are connected to immovable walls with a spring of constant " $2k$ " and " $k$ " respectively, as shown in Fig 4. The masses are coupled to each other with an elastic band of length  $L$ , under tension  $T = 2kL$ . The masses are constrained to move in the  $x$  direction only. The springs are uncompressed, when the masses have same  $x$  position. There is no friction or gravity. The displacements from equilibrium are small enough ( $x_1, x_2 \ll L$ ), so that the tension in the band stays constant. Find the differential equations of motion describing the displacement of the masses.

**08 Marks**



**Fig 4**

**Q5** A light hollow shaft BC is attached to a disc of mass  $M$  and radius  $R$  at one end and a point mass ' $m$ ' at the other end. The shaft is supported by a thin bearing at  $O$  connected to a light vertical rod AO. The bearing allows the shaft to rotate about the  $x$  and  $y$  axes shown. Also, the rotation of rod OA about the  $z$  axis is transmitted to the shaft BC by the bearing. Rod OA rotates at the rates  $\omega_\alpha$  and  $\dot{\omega}_\alpha$  as shown while the shaft BC rotates about its axis at rates  $\omega_\beta (>0)$  and  $\dot{\omega}_\beta$  as shown. The bearing applies a frictional moment,  $M_f$ , on rod BC, along its axis.



**Fig 5**

(a) Show that the axes, ( $x, y$  and  $z$ ) are principal axes at  $O$  for the rigid body BOC (including the disc and point mass).

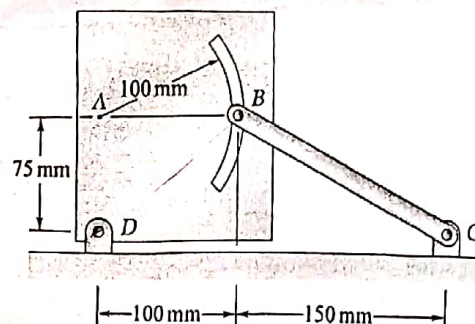
**Determine:**

- The total angular velocity and angular acceleration of shaft BC with respect to the ground frame.
- The torque  $T_0$  required to maintain this motion.
- The mass ' $m$ ' needed to maintain the shaft BC horizontal i.e. no tendency to rotate about the ' $y$ ' direction.
- $\dot{\omega}_\beta$  at this instant.

**12 Marks (2, 3, 2, 3, 2)**

**Q6** At the instant shown in Fig 6, the bar BC has an angular velocity of  $3 \text{ rad/s}$  and an angular acceleration of  $2 \text{ rad/s}^2$ , both clockwise, determine the angular acceleration of the plate as shown below.

**12 Marks**



**Fig 6**