University of Moratuwa

Department of Mechanical Engineering

B.Sc. Engineering, Semester 1 (Batch 20)

ME1033 Mechanics (**DYNAMICS**)

Tutorial 02 – **Kinematics of Rigid Bodies, Instantaneous Centre of Rotation**

Question 1

Each of the sliding bars *A* and *B* engages its respective rim of the two riveted wheels without slipping as shown in Figure *Q*1. Determine the magnitude of the velocity of point *P* for the position shown.

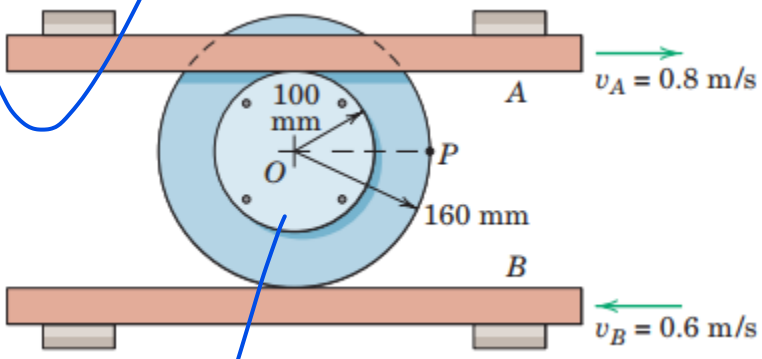

Figure *Q*1

Question 2

Horizontal motion of the piston rod of the hydraulic cylinder controls the rotation of link *OB* about *O* as shown in Figure *Q*2. For the instant shown, v_A = 2 m/s and *OB* is horizontal. Determine the angular velocity of *OB* for this instant.

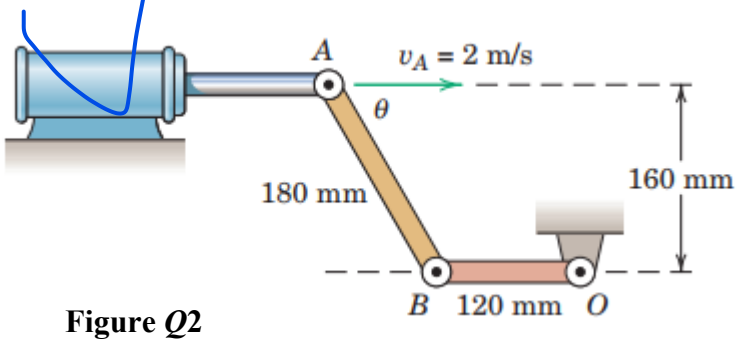

Figure *Q*2

Question 3

The sliding rails *A* and *B* engage the rims of the double wheel, shown in Figure *Q*3, without slipping. For the velocities of *A* and *B* shown in the figure, determine the angular velocity of the wheel and the magnitude of the velocity of point *P*.

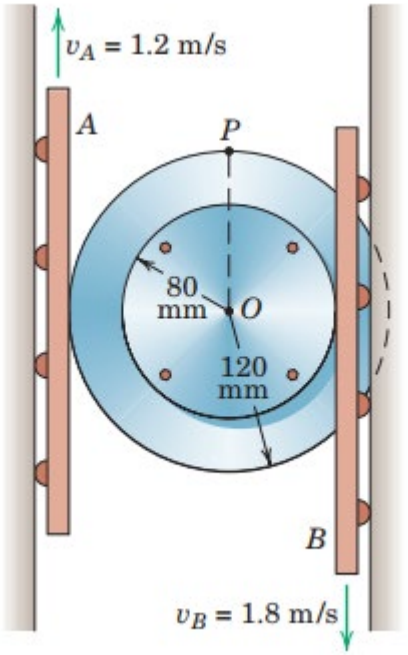

Figure *Q*3

Question 4

The large roller bearing shown in Figure *Q*4 rolls to the left on its outer race with a velocity of its centre O of 0.9 m/s. At the same time the central shaft and inner race rotate counterclockwise with an angular speed of 240 rev/min. Determine the angular velocity of each of the rollers.

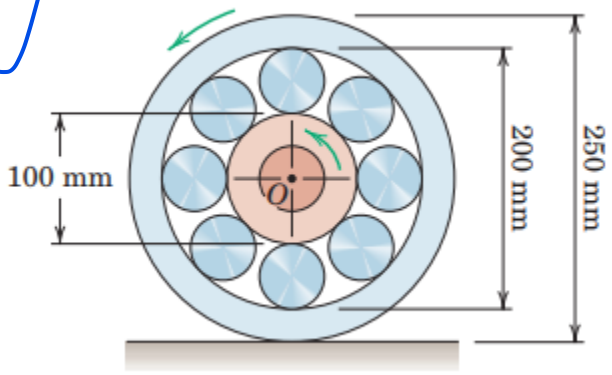

Figure *Q*4

Question 5

Piston-rod *AB* of length 273.2 mm slides in a rotating cylinder at a uniform sliding velocity (relative to the cylinder) v_s = 1 m/s, downwards, as shown in Figure *Q*5. The cylinder rotates about fixed point *O* at a constant angular velocity ω = 10 rad/s in clockwise. At the instant shown, *OA* = 100 mm, and *OAB* makes an angle of 45^0 to the horizontal. Determine the absolute velocities of points *A* and *B* of the piston-rod for the instant shown. Locate the instantaneous centre of rotation of the piston-rod.

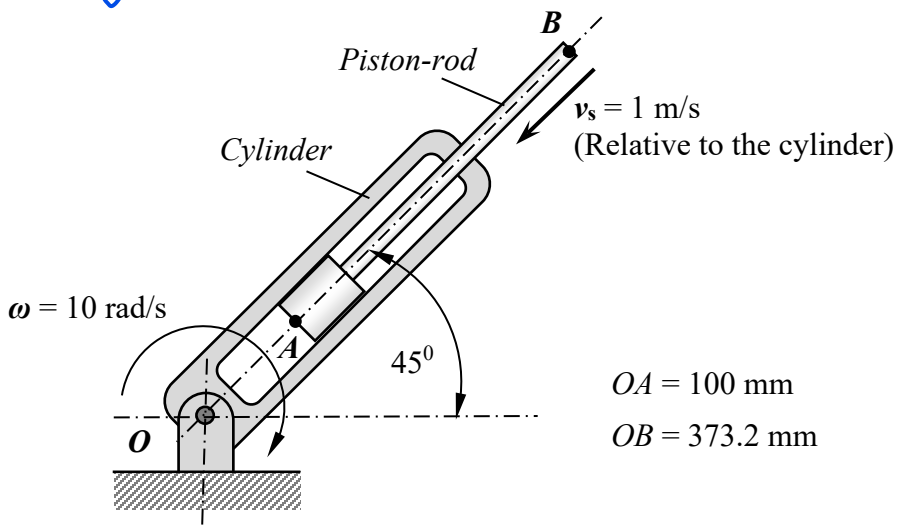

Figure *Q*5

Question 6

Piston rod *AB* of an actuator is sliding in a cylinder as shown in Figure *Q*6. The cylinder is rigidly fitted to crank *OA*. The crank-cylinder unit rotates at a uniform speed of 4 rad/s clockwise about fixed axis *O* as shown. The piston rod slides at a uniform speed of 0.1 m/s outwards, relative to the cylinder. At the instant shown, *OB* is vertical, and *AB* makes an angle of 30^0 with the vertical. *OA* is 100 mm. Find the location of the instantaneous centre of rotation of piston rod *AB*. Using the location of the instantaneous centre of rotation obtained, determine the angular velocity of piston rod AB.

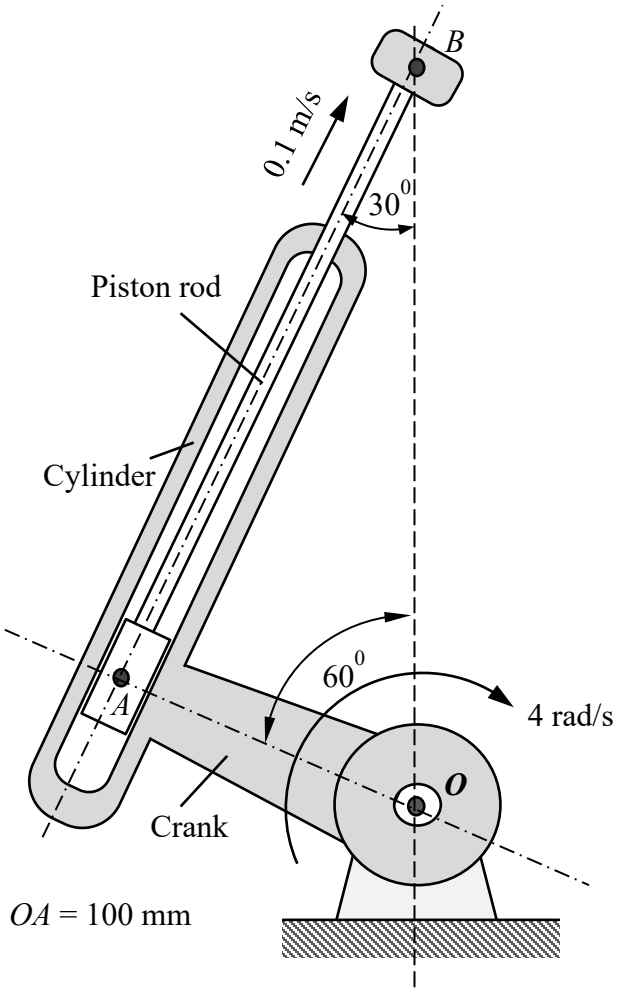

Figure *Q*6

2016

Question 7

Two rollers of radii 0.2 m and 0.3 m are pivoted at two ends *A* and *B* of a rigid curved rod respectively as shown in Figure *Q*7. Roller at *A* is in contact with a fixed convex cylindrical surface of radius 1.2 m and roller at *B* is in contact with a fixed horizontal surface as shown. At the instant shown, roller at *B* has an angular velocity of 5 rad/s in clockwise. Assume both rollers do not slip over their contact surfaces. Find the position of the instantaneous centre of rotation of the rod. Hence determine the angular velocity of the rod for the instant shown. Also find the absolute velocity of point *A* and the angular velocity of the roller at *A*.

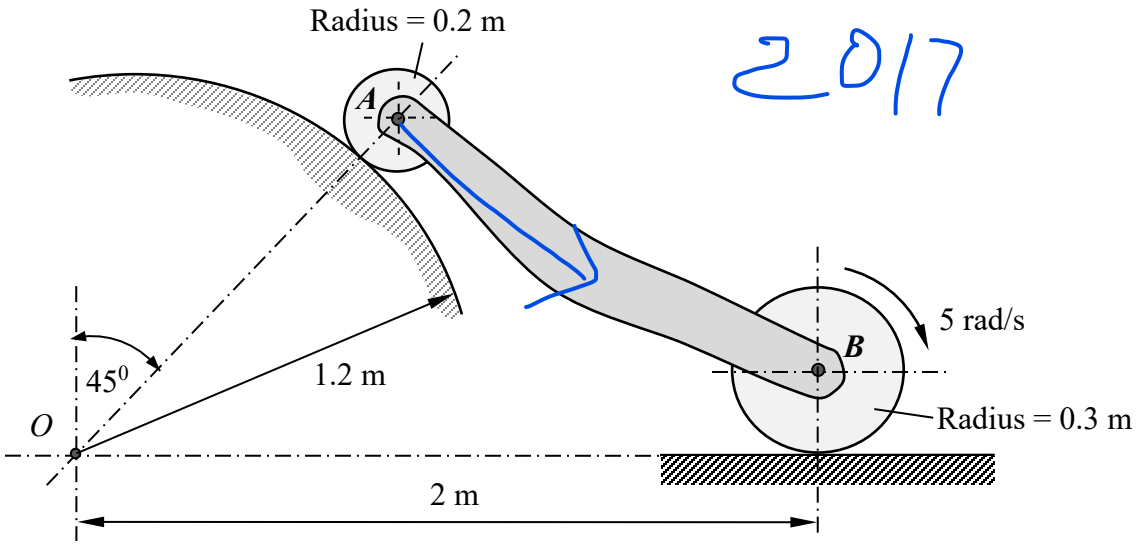

Figure *Q*7

Question 8

The shaft at *O* drives arm *OA* clockwise at a speed of 90 rev/min about the fixed bearing at *O* as shown in Figure *Q*8. Use the method of instantaneous centre of zero velocity to determine the rotational speed of gear B if, (i) annular gear *D* is fixed and (ii) annulus *D* rotates counterclockwise about *O* with an angular speed of 80 rev/min.

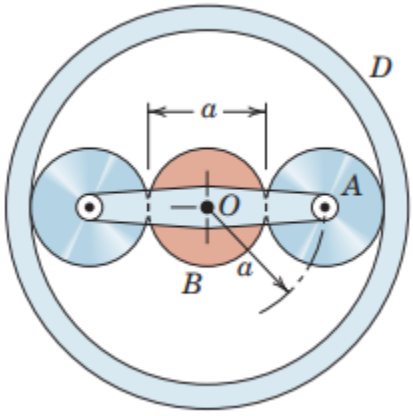

Figure *Q*8

Question 9

Figure *Q*9 shows a schematic diagram of a part of an epicyclic gear train consisting of an annular wheel *A* of effective radius 4*r* and a planet wheel *P* of radius *r*. The annular wheel can rotate freely about fixed axis *O*. Lever *L* carries the planet wheel and can independently rotate about axis *O* as shown. The planet wheel is free to rotate relative to the lever about axis *Q*. For the instant shown, the absolute angular velocities of the annular wheel and the lever are ω_A and ω_L respectively, both in clockwise.

(a) Show that the absolute angular velocity of the planet wheel ω_P is given by,

$$\boldsymbol{\omega_P = (4\omega_A - 3\omega_L)}$$

(b) Use the expression of ω_P obtained in part-(a) above to show that the distance to the instantaneous centre of rotation of planet wheel P from its centre *Q* along the centre line *OQ* is

$$\frac{\boldsymbol{3r}}{\left[\boldsymbol{4\left(\frac{\omega_A}{\omega_L}\right) - 3}\right]}$$

(c) What is the centrode (Locus of the instantaneous centres of rotation) of wheel *P*?

(d) Briefly explain the type of motion of the planet wheel when $\omega_A = 0.75\,\omega_L$

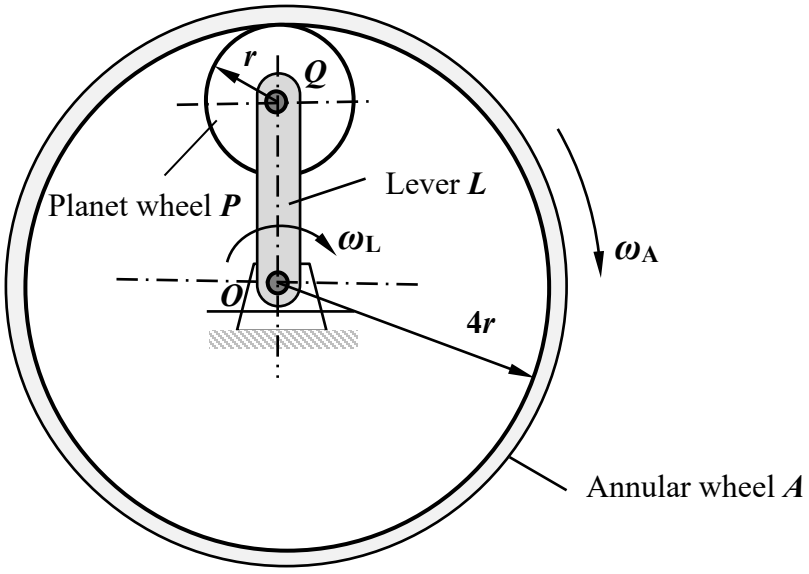

Figure *Q* 9