1. (30%) A particle is moving along a path on the XY plane from point A to point D, as shown in Fig. 1. The path consists of 3 segments: a straight line from A to B, a circular arc of radius $\sqrt{2}$ mm from B to C, and a straight line from C to D. Suppose that the particle is moving with a constant speed of $2\sqrt{2}$ mm/sec along the path. The coordinates from A to D are

   A(-2, 2); B(-1, 1); C(1, 1); D(2, 2)  (unit: mm)

   (a) (20%) Please determine the velocity and acceleration of the particle from point A to point D, expressed in X and Y components, respectively, i.e., find $v_X(t), v_Y(t), a_X(t), a_Y(t)$.

   (b) (10%) Please plot your results, i.e., plot $v_X(t), v_Y(t), a_X(t), a_Y(t)$ versus time.

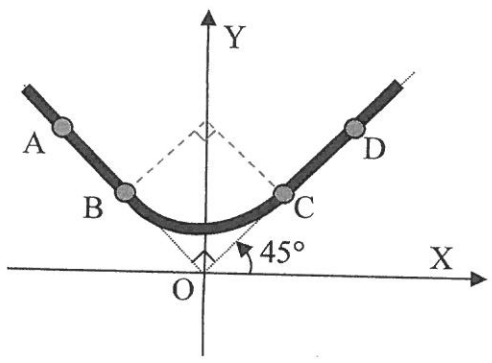


Fig. 1

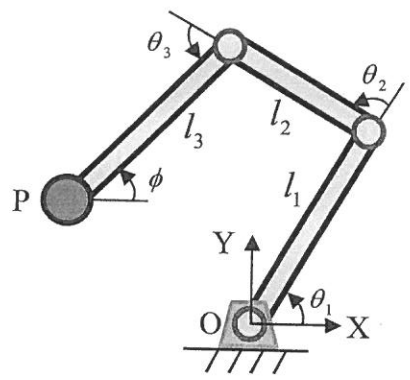


Fig. 2

2. (20%) Consider a 3-link robot arm with lengths of $l_1, l_2, l_3$, respectively, as shown in Fig. 2. Please determine the position (denoted as $(x_P, y_P)$) and orientation angle $\phi$ of the end-effector P, in terms of the 3 joint angles $\theta_1, \theta_2, \theta_3$.

3. (15%) The link shown in Fig. 3 below is guided by two blocks A and B which move in the fixed slots. If the velocity of A is 2 m/s downward, please determine the velocity of B at the instant $\theta$=45° .

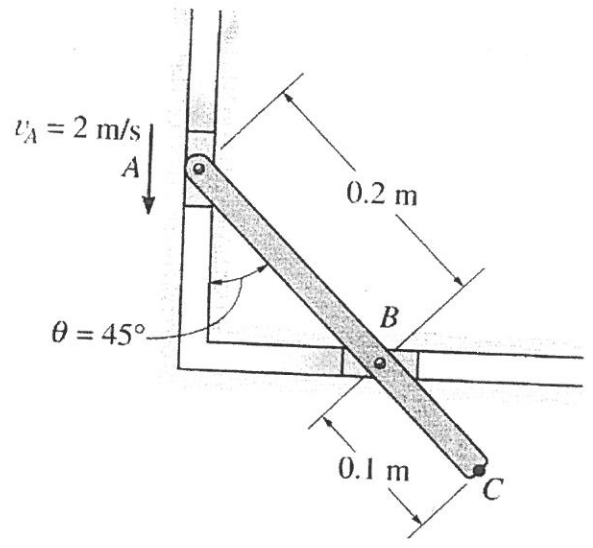


Fig. 3

4. (20%) The drum of radius 0.4 m shown in Fig. 4 has a mass of 60 Kg and a radius of gyration $k_O$=0.25 m. A cord of negligible mass is wrapped around the periphery of the drum and attached to a block having a mass of 20 Kg. If the crate is released, please determine the drum's angular acceleration.

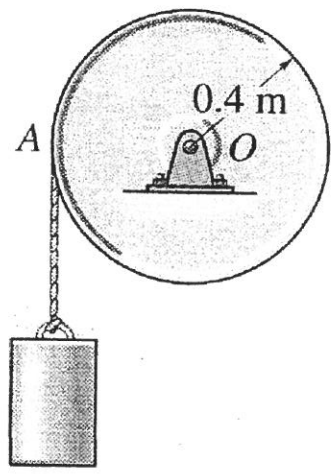


Fig. 4

5. (15%) A typical mass-damper-spring system is driven by a force f(t) shown in Fig. 5, where x(t) is the displacement of the mass M, M=1kg, C=10 Nt/(m/sec), K=400 Nt/m.
   (a) (10%) Please derive the equation of motion.
   (b) (5%) Find the undamped natural frequency.

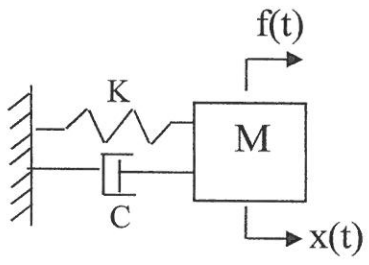


Fig. 5