Mechanics of rigid bodies 1

Series 2. Kinematics

Exercise 1

Consider the helical movement of a helicopter around the Z_0 axis (figure 1). We have $O_0O_1 = d$, $O_1O_2 = h(t)$ and $O_2M = r$. The angular velocities $\dot{\psi}$ and $\dot{\theta}$ are constants.

Calculate by differentiation:

1. The angular velocity of R_2 and the velocity of O_1 and M with respect to R_0 expressed in R_1.
2. The velocity of O_2 with respect to R_1 expressed in R_1.
3. The velocity of M with respect to R_1 expressed in R_1, and then, using the transition matrix, express this vector in R_2 and R_0.
4. The acceleration vector of M with respect to R_0 expressed in R_1.

Exercise 2

A double pendulum consists of two rods OA and AB, pined at point A (Figure 2). The rod OA, pined at point O, undergoes a rotational movement around the z_0 axis. The rod AB undergoes a rotational movement around z_1. We have: $OA = a$ and $AB = b$.

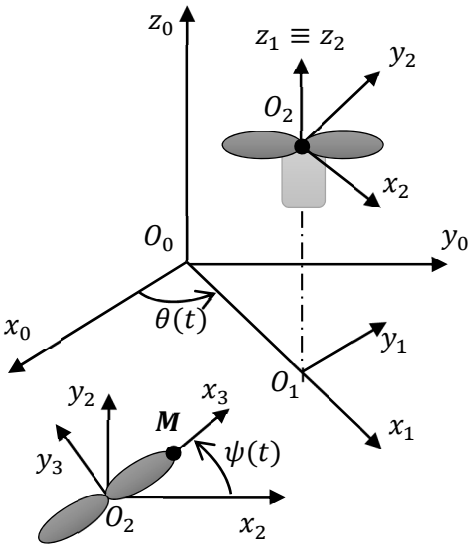

Figure 1

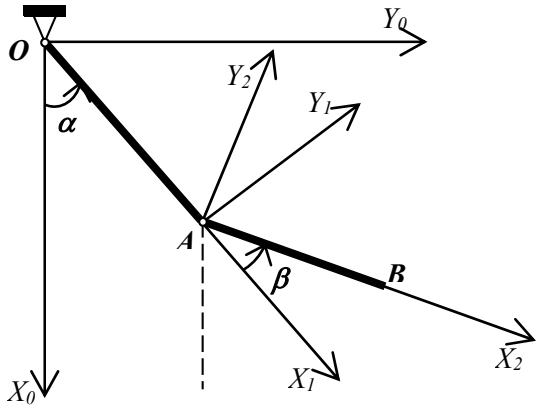

Figure 2

Part 1. R_1 is the projection frame.

1. Determine, by differentiation:
   a. The absolute velocity of A.
   b. The absolute acceleration vector of A.
2. Determine, using the kinematics of the solid (using answers of question 1):

a. The absolute velocity vector of B.

b. The absolute acceleration vector of B.

Part 2. Express the absolute velocity vector of B, calculated in question 2a, in the frame R_0, using the transition matrix

Exercise 3

The L-shaped arm BCD rotates about the z axis with a constant angular velocity $\omega_1 = 5\,rad/s$ (Figure 3). Knowing that the $150 - mm - radius$ disk rotates about BC with a constant angular velocity $\omega_2 = 4\,rad/s$, determine with respect to time:

a) the velocity and acceleration of point A, by differentiation
b) the velocity and acceleration of point B, by differentiation
c) the velocity and acceleration of point A, , using the kinematics of the solid (using answers of b)

Exercise 4

The rectangular plate shown in (Figure 4) rotates at the constant rate $\omega_2 = 12\,rad/s$ with respect to arm AE, which itself rotates at the constant rate $\omega_1 = 9\,rad/s$ about the Z axis. Determine the velocity and acceleration with respect to time t of the corners B and C.

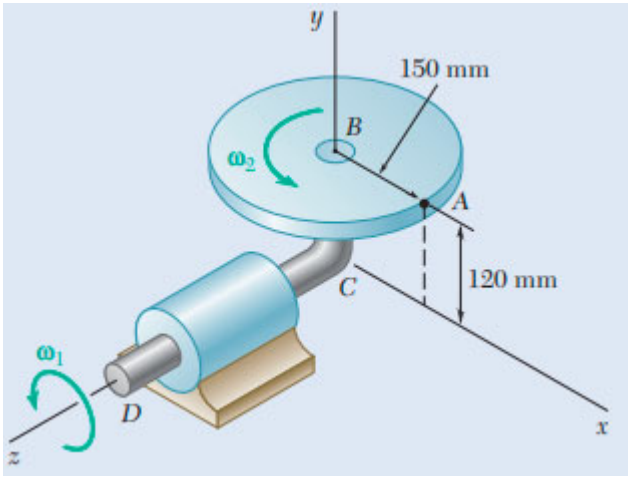

Figure 3

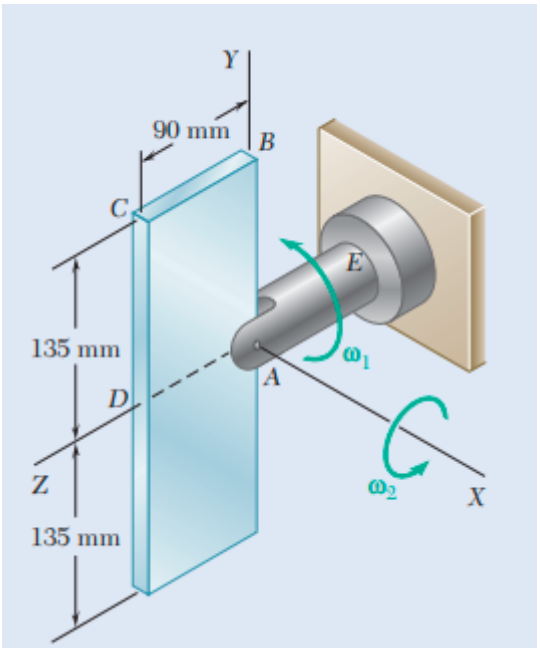

Figure 4