

# Solid Mechanics 2 Tutorial Sheets

Tutorial Sheets and Answers for DE2's Enjoyment

## Tutorial Sheet 2: Planar Kinematics with Acceleration

### Topics covered are

- Acceleration in 2D
- Relative accelerations

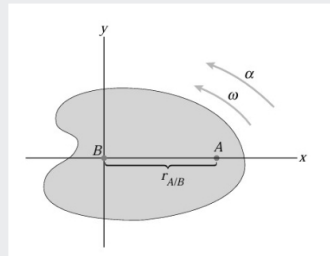
### Tips

- The questions start to get quite wordy. Drawing it all out helps!
- Because we are dealing with 2D planar motion, it does not matter which relative acceleration formula we use - the one using  $\omega \times \omega$  or  $\omega^2$ . When expanding to 3D, only  $\omega \times \omega$  works, but for the moment  $\omega^2$  is faster.

### Question 1

The rigid body rotates about the z axis with counterclockwise angular velocity  $\omega = 4 \text{ rad/s}$  and counterclockwise angular acceleration  $\alpha = 2 \text{ rad/s}^2$ . The distance  $r_{A/B} = 0.6 \text{ m}$ .

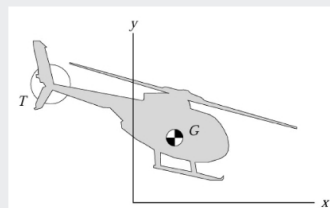
- (a) What are the rigid body's angular velocity and angular acceleration vectors?  
(b) Determine the acceleration of point A relative to point B.



### Question 2

The helicopter is in planar motion in the xy plane. At the instant shown, the position of its center of mass G is  $x=2 \text{ m}$ ,  $y=2.5 \text{ m}$ , its velocity is  $v_G = 12i + 4j \text{ m/s}$ , and its acceleration is  $a_G = 2i + 3j \text{ m/s}^2$ . The position of point T where the tail rotor is mounted is  $x=-3.5 \text{ m}$ ,  $y=4.5 \text{ m}$ . The helicopter's angular velocity is  $0.2 \text{ rad/s}$  clockwise, and its angular acceleration is  $0.1 \text{ rad/s}^2$  counter-clockwise.

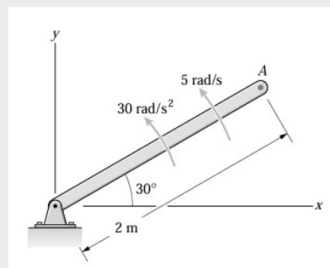
What is the acceleration of point T?



### Question 3

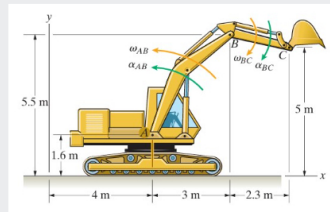
The bar rotates with a counterclockwise angular velocity of  $5 \text{ rad/s}$  and a counterclockwise angular acceleration of  $30 \text{ rad/s}^2$ . Determine the acceleration of A using

$$a_A = a_B + \alpha \times r_{A/B} + \omega \times (\omega \times r_{A/B}).$$



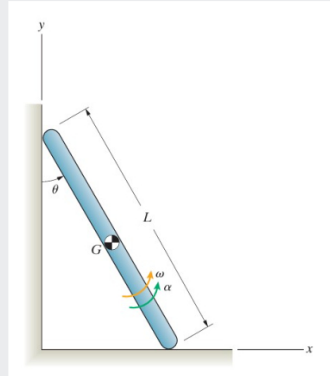
### Question 4

If  $\omega_{AB}=2\text{rad/s}$ ,  $\alpha_{AB}=2\text{rad/s}^2$ ,  $\omega_{BC}=-1\text{rad/s}$ , and  $\alpha_{BC}=-4\text{rad/s}^2$ , what is the acceleration of point C where the scoop of the excavator is attached?



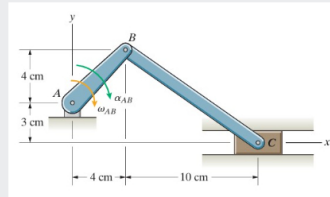
### Question 5

The length of the bar is  $L = 4\text{ m}$  and the angle  $\theta = 30^\circ$ . The bar's angular velocity is  $\omega = 1.8\text{ rad/s}$  and its angular acceleration is  $\alpha = 6\text{ rad/s}^2$ . The endpoints of the bar slide on the plane surfaces. Determine the acceleration of the midpoint G.



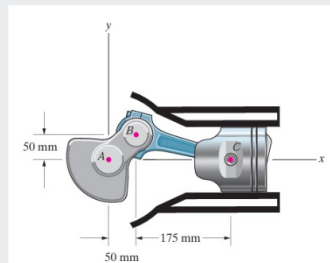
### Question 6

The angular velocity's magnitude  $\omega_{AB} = 6\text{ rad/s}$ . If the acceleration of the slider C is zero at the instant shown, what is the angular acceleration  $\alpha_{AB}$ ?



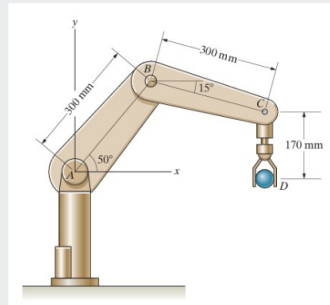
### Question 7

At the instant shown, the piston's velocity and acceleration are  $v_C = -14i\text{ m/s}$  and  $a_C = -2200i\text{ m/s}^2$ . What is the angular acceleration of the crank AB?



### Question 8

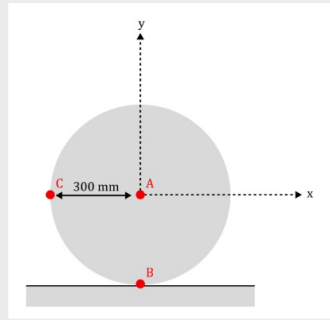
If arm AB has a constant clockwise angular velocity of  $0.8\text{ rad/s}$ , arm BC has a constant angular velocity of  $0.2\text{ rad/s}$ , and arm CD remains vertical, what is the acceleration of part D?



### Question 9

### Question 9

Point A of the rolling disk is moving toward the right and accelerating toward the right. The magnitude of the velocity of point C is 2 m/s, and the magnitude of the acceleration of point C is  $14 \text{ m/s}^2$ . Determine the angular acceleration of the disk.



### Question 10

The disk rolls on the circular surface with a constant clockwise angular velocity of 1 rad/s. What are the accelerations of points A and B?

