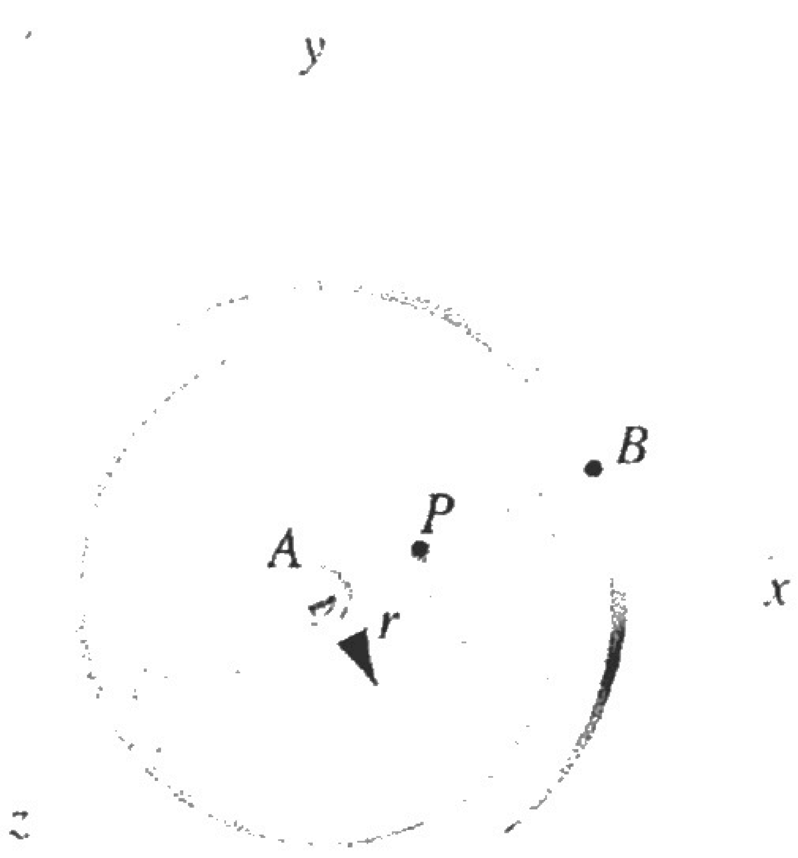
Introduction to Rotational Motion

During Semester I we studied linear motion. Now instead of objects moving in lines they will be rotating in circles. Some examples of objects we will study are wheels, merry-go-rounds, and CDs. All of the quantities we applied to linear motion will have angular equivalents.

Instead of linear displacement, x, we have angular displacement θ.
θ is measured in radians and is positive if the object rotates counter-clockwise (the order of the quadrants).
If an object makes 3 revolutions the angular displacement is 6π, not zero. We never reset it. Sometimes the angular displacement is expressed in revolutions instead of radians. We can convert to the SI unit of radians by recognizing that 1 rev = 2π radians.

Instead of linear velocity, v, we have angular velocity ω.
(This is also known as angular frequency – it's the same ω from last unit.)
Angular velocity is measured in radians/second.



How is linear displacement related to angular displacement?
In a given time period, points B and P have had the same change in radians but have traveled different linear distances. B travels farther because it has a greater radius. Using the formula for arc length, the distance it traveled is given by:

$x = \theta r$

This will be how we convert from angular to linear quantities. Take the angular quantity and multiply it by the radius at that location.

$v = \omega r$

Lastly, instead of linear acceleration, a, we have angular acceleration α.
Angular acceleration is measured in radians/second^2.

$a = \alpha r$

All rotating objects have centripetal acceleration because they are moving in a circle. A rotating object will have angular acceleration in addition to that if it has tangential acceleration as well. In other words, if a wheel is getting faster and faster it has both radial (centripetal) acceleration and angular acceleration.

Recap
1. All points on a rotating wheel will have the same ____________ but different ______________.

2. A wheel rotating at constant speed has ______________ but not ______________.

Examples
1. A wheel initially rotating at 2.0 rad/s experiences a constant angular acceleration of 3.5 rad/s^2 for 4.0 seconds. The radius of the wheel is 0.45 m.
   a. What is the final angular speed of the wheel?
   b. What is the final linear speed of the wheel's rim?
   c. How many revolutions does the wheel make during the 4.0 s time interval?

2. The angular position of a point on a rotating wheel is given by $\theta = 2 + 4t^2 + 2t^3$.
   a. What is the average angular velocity of the wheel during the first 3 seconds?
   b. What is the angular acceleration at t = 2 seconds?
   c. Is the angular acceleration constant?

	Linear	Angular
Displacement		
Velocity		
Acceleration		
Ave. Velocity		
Inst. Velocity		
Three Formulas		
Inertia		
Newton's 2nd Law		
Kinetic Energy		
Momentum		

PS1 pg. 317 (3, 6, 7, 8, 18, 19)

3. An airliner arrives at the terminal, and its engines are shut off. The rotor of one of the engines has an initial clockwise angular speed of 2000 rad/s. The engine's rotation slows with an angular acceleration of magnitude 80.0 rad/s^2.
   a. Determine the angular speed after 10.0 s.
   b. How long does it take for the rotor to come to rest?

6. A centrifuge in a medical laboratory rotates at a rotational speed of 3600 rev/min. When switched off, it rotates 50.0 times before coming to rest. Find the constant angular acceleration of the centrifuge.

7. The angular position of a swinging door is described by $\theta(t) = 5.00 + 10.0t + 2.00t^2$ rad. Determine the angular position, angular speed, and the angular acceleration of the door at
   a. t = 0s
   b. t = 3.00s

8. The tub of a washer goes into its spin cycle, starting from rest and gaining angular speed steadily for 8.00 s, when it is turning at 5.00 rev/s. At this point the person doing the laundry opens the lid, and a safety switch turns off the washer. The tub smoothly slows to rest in 12.0 s. Through how many revolutions does the tub turn for the 20 s it is in motion?

18. A 6.00-kg block is released from A on the frictionless track shown in figure P10.18. Determine the radial and tangential components of acceleration for the block at P. (See bottom of page.)

19. A disc 8.00 cm in radius rotates at a constant rate of 1200 rev/min about its central axis. Determine:
   a. Its angular speed
   b. The linear speed at a point 3.00 cm from its center
   c. The radial acceleration of a point on the rim
   d. The total distance a point on the rim moves in 2.00 s

(Q.18)

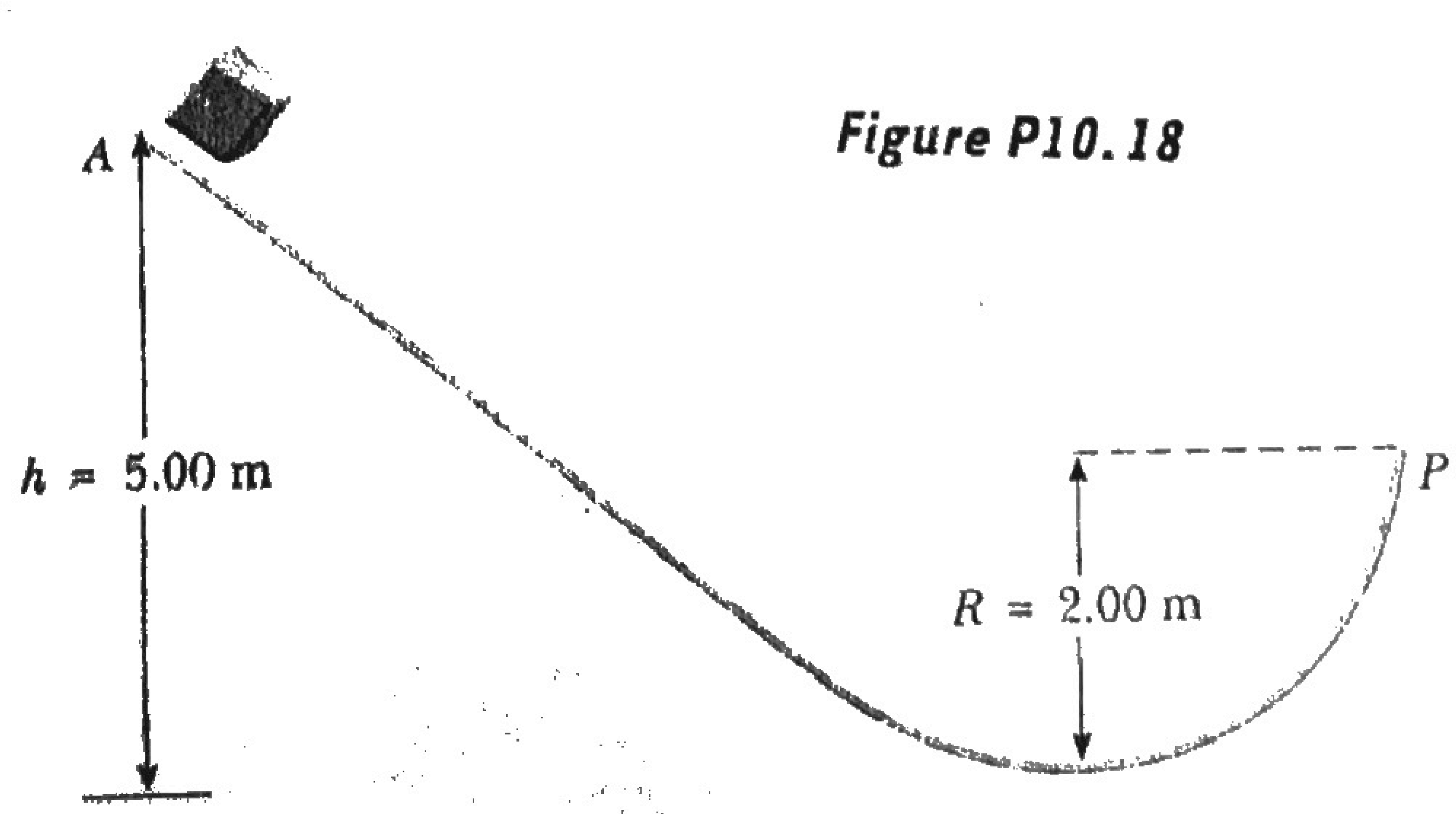


Figure P10.18