Physics Workshop | **Mechanics Tutorial** **Rotational Kinematics** | **Number 8**

Useful Equations and Relations:

Rotational Motion

$2\pi\ rad = 1 rev$

$l = r\theta,\ v = r\omega,\ a_{\tan} = r\alpha$

$\omega = \omega_0 + \alpha t$

$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$

$\omega^2 = \omega_0{}^2 + 2\alpha(\theta - \theta_0)$

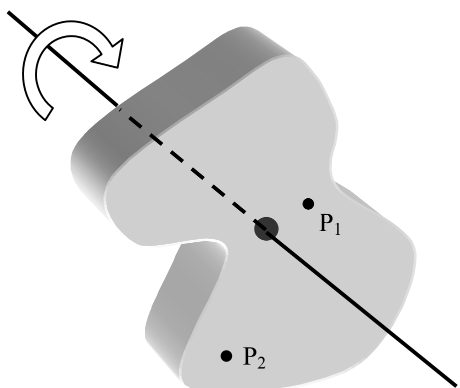
$\tau = Fr_\perp$

$\Sigma\tau = I\alpha$

In your work in Tutorial, please remember to

1) Draw pictures and/or diagrams of the situation before beginning a solution.
2) Write down the known quantities and the desired unknown(s).
3) Start your solution by writing down a fundamental relation or equation that you think is relevant.

1. Consider a clockwise-rotating object, such as the odd-shaped one shown below. The large black mark near the center of the object represents the point around which it is rotating, and the line through that point is called the axis of rotation of the object. P_1 and P_2 represent arbitrary points on the object's surface.



(a) Describe the trajectories of the points P_1 and P_2. What is different about these trajectories?
(b) Will the points P_1 and P_2 be moving with the same velocities? If not, what are the differences?
(c) Supposing the object is rotating at constant speed, are the points P_1 and P_2 accelerating? If so, are their accelerations the same, or not?
(d) Now imagine that the object is speeding up in its rotation (rotating faster and faster with time). Carefully sketch the acceleration vectors for the points P_1 and P_2 on the diagram.
(e) What are the quantities that the points P_1 and P_2 have in common?

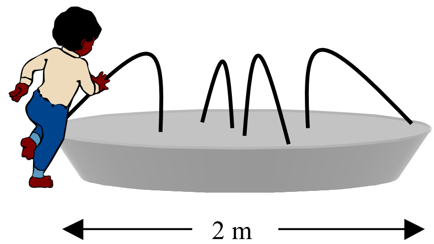
Check Point

2. Translate the following quantities into plain language that someone with very little knowledge of mathematics could easily understand. That is, describe what these quantities really mean in non-technical terms.

(a) One radian (1 rad)
(b) Twelve and a half radians per second (12.5 rad/s)
(c) Six radians per second squared (6 rad/s^2)

Check Point

3. Frankie is playing on a playground merry-go-round. He pushes on the railing at its edge and gives the merry-go-round a constant angular acceleration of ½ rad/s^2 for 10 seconds. The diameter of the merry-go-round is 2 meters.

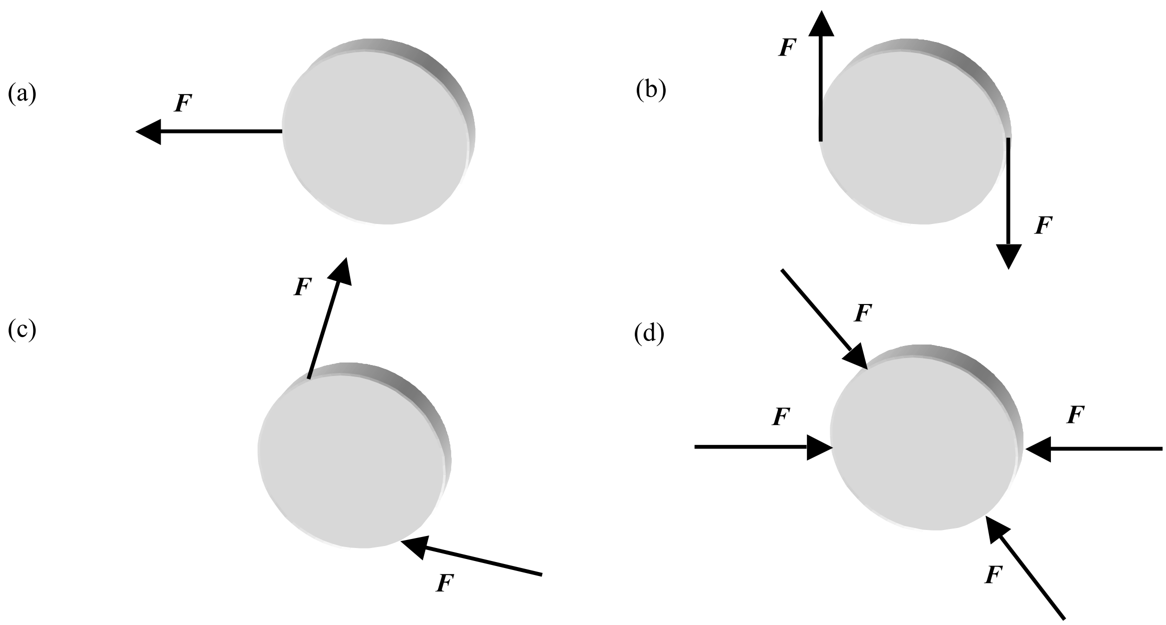


(a) Find the number of rotations made after 10 seconds.
(b) How far has Frankie run after 10 seconds?
(c) Find the angular speed of the rotating merry-go-round after 10 seconds.
(d) How fast is Frankie running after 10 seconds? Is this realistic?

Check Point

4. Consider a circular object that is free to rotate about its central axis, like a car's steering wheel. An important question is, what exactly causes such an object to start rotating, or more precisely to change its rate of rotation? Is it a net force, which is the cause of changes in linear motion, or is it something else?

The diagrams below show such an object with various forces applied to it. In each case, will the object rotate? Will it accelerate linearly? Or perhaps it will do both, or neither. In each case, carefully describe the resulting motion of the object, assuming that the forces shown are the *only* forces acting upon it.



(e) Referring to your analysis of the above diagrams, what can you conclude about the cause of rotational (or angular) acceleration? [In physics we refer to this cause as a net torque.]

Check Point

Additional Questions

1. Consider a ball rolling down a hill. Make a free-body diagram for the ball. Which force causes the ball to rotate? Which force causes it to accelerate down the hill?

2. Imagine that you are trying to turn the wheel that opens the escape hatch on your sinking submarine. It is a matter of life and death, and the wheel seems to be stuck. You are able to exert a certain amount of force with each hand, but no more. Describe how you would use these forces to your best advantage in order to turn the wheel. Be creative; your life depends on it!