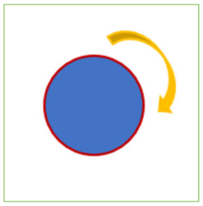
Rotational Kinetics, Rotational Energy Into

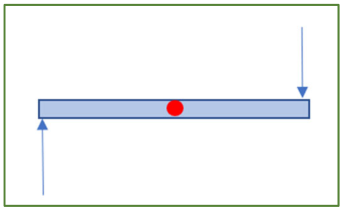
1. *Translating objects* with no net force move linearly at constant speed with acceleration a = _________. Acceleration is caused by net force and resisted by mass in accordance with Newton's 2nd law. Compute the following chart.

Quantity	**Acceleration**	**Net Force**	**Mass**
SI unit			
BG unit			



2. For rotation, the analogy of net force is torque or Moment, that of mass is rotational inertia or moment of inertia, and that of translational acceleration is angular acceleration. *Rotating objects* with no net torque turn at constant angular _____________________ , i.e. with angular acceleration α = ________________.

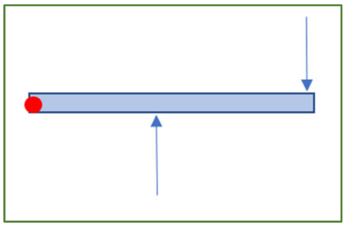
3. In each case, calculate the net Moment or torque produced by the forces around the axis at A (the red dot). Assume the mass of the bar is negligible (not always a valid assumption!). Your answer should include units.



a) The bar is 1 meter long, axis at midpoint. Each force is 10 Newtons acts at both at the end of the bar and perpendicular to the bar. Note that torque has a direction (clockwise or counterclockwise … CCW).

b) Repeat if the right force acts upwards instead of downwards.

c) The bar to the right is 2 feet long, axis at left. Each force is 25 pounds and acts perpendicular to the bar with one force at the midpoint and the other at the right end.



d) Repeat if the right force acts downwards instead of upwards.

Objects also have rotational inertia or "moment inertia" symbolized by "I." An object with a large "I" resists changes in rotational motion: it's hard to increase or decrease the ω of an object with a large "I." For a point mass rotating about an axis, $I = m*r^2$ where "r" is the distance the mass is from the pivot or axis of rotation. You can add masses; you can add "I's" as well.

4. In the bar/mass combination to the left, the 4 meter rod's mass is negligible. Each "small" ball has mass 4 kg. a) Find I

i. for the axis through the center of the rod and perpendicular to the rod.
ii. for the axis through one of the balls and perpendicular to the rod
iii. for the axis through a point 0.5 meters from one of the balls and perpendicular to the rod.

b) What if the rod where 8 meters long instead (mass still each 4 kg). What would be "I" about the axis through the center of the rod and perpendicular to the rod?

5. When mass is "spread out" we can determine I using integration or formulae. Find the moment of inertia I (using appendix D formulae) of

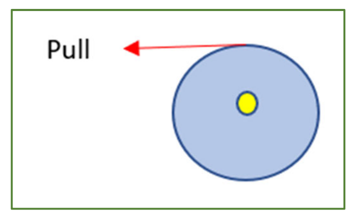
a) a 10 kg solid cylinder of diameter 80 cm rotating about the z-axis.
b) a 10 kg hollow cylinder of diameter 80 cm rotating about the z-axis.
c) a 10 kg solid sphere of diameter 80 cm rotating about its center.
d) a 20 kg rod of length 2 meters rotating about its midpoint.
e) a 20 kg rod of length 4 meters rotating about its midpoint.
f) a 20 kg rod of length 4 meters rotating about its end.

6. Angular acceleration is caused by net torque or Moment in accordance with Newton's 2nd law: ***α = net τ/I***. Complete the following chart.

Quantity	**Net torque**	**Rotational inertia**	**Angular acceleration**
SI unit			
BG unit			

7. The diagram to the right represents a solid disk which rotates freely about a central axel. A light rope is wrapped about it; you grab the end of the rope and pull to the left. Determine the disk angular acceleration if

a) the disk has mass 2 kg, diameter 40 centimeters and your pull is 10 N.
b) the disk has mass 2 kg, diameter 80 centimeters and your pull is 10 N.
c) the disk has weight 322 pounds, diameter 2 feet and your pull is 120 pounds
c) the disk has weight 161 pounds, diameter 1 foot and your pull is 180 pounds



8. The formula for rotational KE is analogous to that of translational KE.

KE_{trans} = ____________________ KE_{rot} = ________________________.

9. Find the rotational KE of the following objects

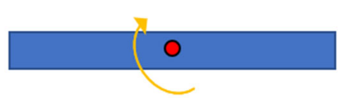
a) The 4 kg cylinder to the right if it

i. is solid with diameter 40 cm and rotates at 120 rpm about its central axis
ii. is hollow with diameter 80 cm and rotates at 240 rpm about its central axis

(answer in joules).

b) The 64.4 slug bar to the right if it

i. has length 2 feet and rotates at 60 rpm
ii. has length 4 feet and rotates at 600 rpm *(answer in ft-lb)*.



10. The KE of rolling objects can be calculated by
finding the translation KE using the speed of the center of mass
finding the rotational KE using the rotational rate (in radians/sec)
summing these two KE's. Find the KE of the 10 gg wheel (which rolls to the right without slipping with speed 10 meters/sec.). Its diameter is 60 cm; the wheel can be considered a solid cylinder.