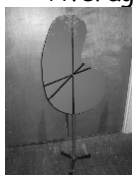
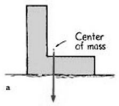
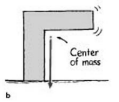
Torque & Rotational Motion

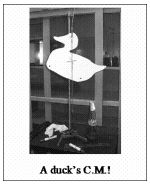
Center of Mass

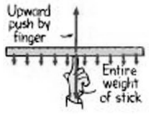
- Average location of an object's mass







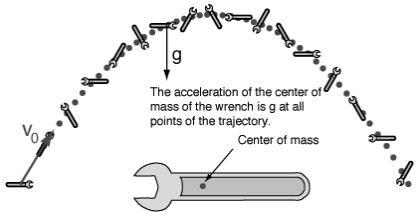




Equilibrium

- A body is in stable equilibrium if it returns to its equilibrium position after it has been displaced slightly
  - Displacement raises cg
- A body is in unstable equilibrium if it does not return to its equilibrium position and does not remain in the displaced position after it has been displaced slightly.
  - Displacement lowers cg
- A body is in neutral equilibrium if it stays in the displaced position after if has been displaced slightly.
  - neither raises nor lowers cg

Center of Mass Path



- Projectile center of mass follows parabolic path.

Fosbury Flop

Dick Fosbury

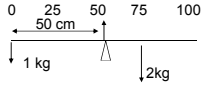
- In the Fosbury Flop, the center of mass of the high jumper actually passes under the bar.

ConcepTest

- A meter stick is suspended at the center. If a 1 kg weight is placed at x=0. Where do you need to place a 2 kg weight to balance it?

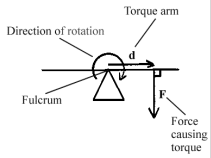
A) x = 25 B) x = 50 C) x = 75 D) x = 100

E) 1 kg can't balance a 2 kg weight.

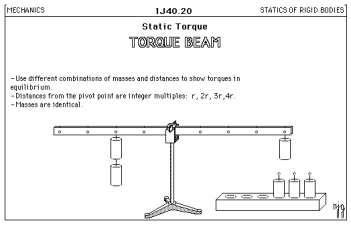


Torque

Torque = Force X Torque Arm



Net Torque = 0 for rotational equilibrium



Torque

- Rotational effect of force. Tells how effective force is at twisting or rotating an object or at changing the rate of rotation.

$\tau = +- r F_{perpendicular} = r F \sin \theta$

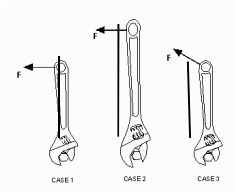
- Units N m
- Sign: CCW rotation is positive

ConcepTest

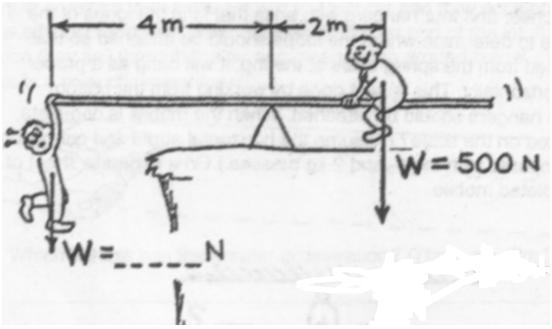
The picture below shows three different ways of using a wrench to loosen a stuck nut. Assume the applied force F is the same in each case.

In which of the cases is the torque on the nut the biggest?

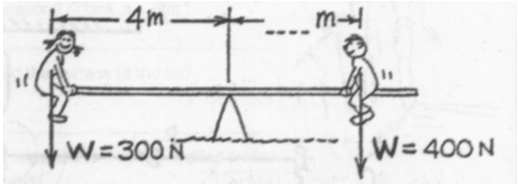
A. Case 1
B. Case 2
C. Case 3



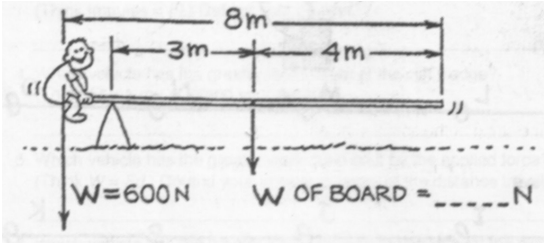
Torque Example 1



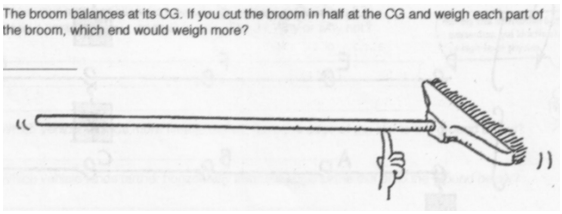
Torque Example 2



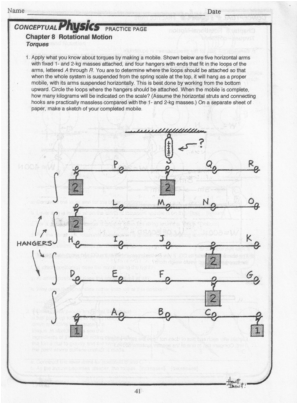
Torque Example 3



ConcepTest



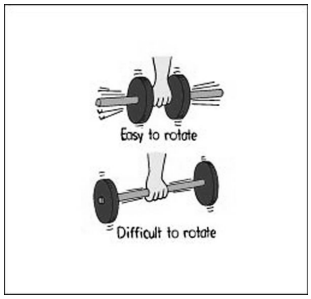
- a. the handle end
- b. the bristle end
- c. they weigh the same



Rotational Inertia

- Resistance to a change in rotational motion
- Depends on the distribution of the mass about the axis of rotation

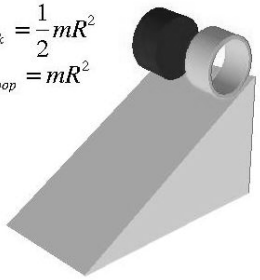
$$\sum mr^2$$



Hoop versus Disk

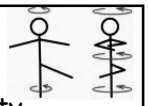
$$I_{disk} = \frac{1}{2}mR^2$$

$$I_{hoop} = mR^2$$



- A solid cylinder will reach the bottom first because of its lesser rotational inertia.

Angular Momentum



- Linear Momentum: mass x velocity
- Angular Momentum:
- rotational inertia x angular velocity

- An object or system of objects will maintain its angular momentum unless acted upon by an unbalanced external torque.