Physics 2514

Lecture 37

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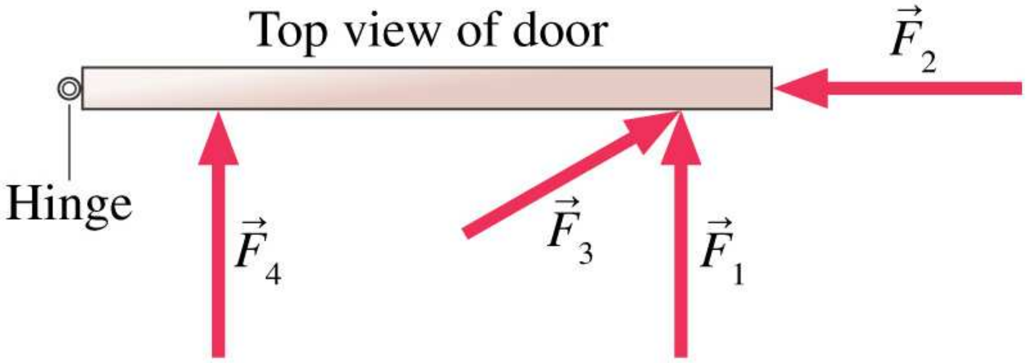
Rotational Forces

- How does one apply Newton's laws to systems that rotate?

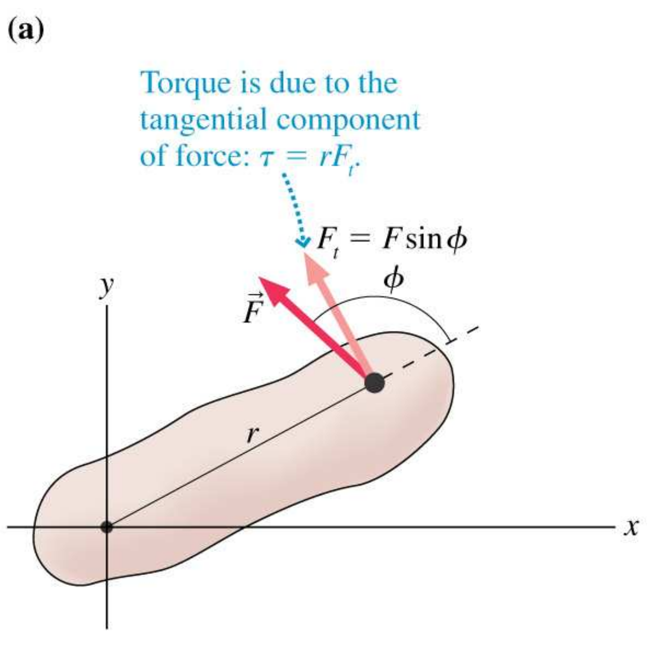
Forces on a Door

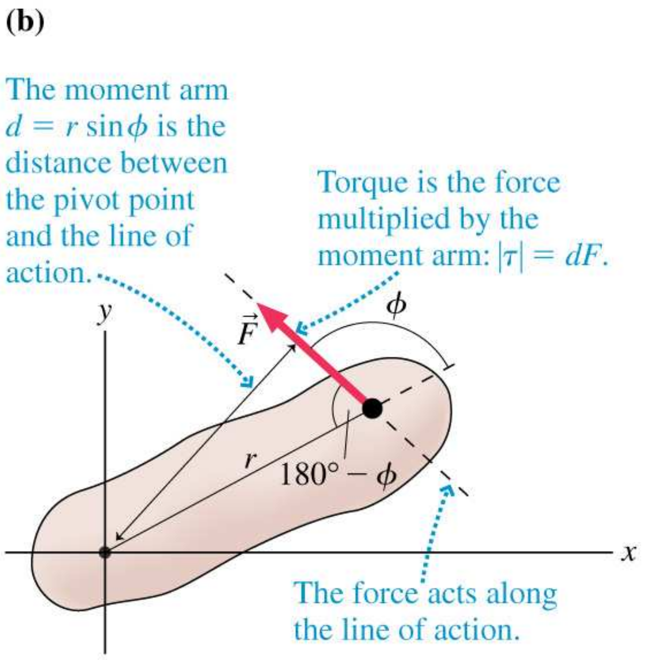


- Experience tells us $\vec{\mathbf{F}}_1$ makes opening the door easier, assuming that all forces have the same magnitude. Force furthest from hinge and perpendicular causes largest acceleration.

Torque

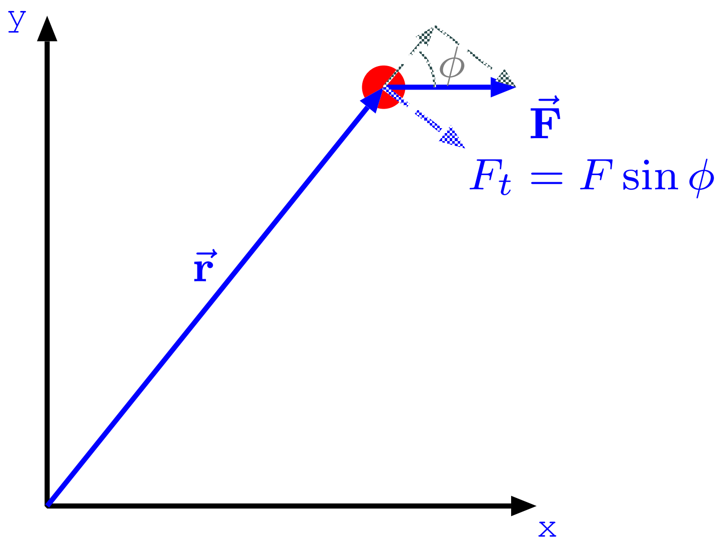
- Define torque $\tau = rF_\perp = r_\perp F = rF\sin\phi$ $F_\perp$ is the component of the force that gives the tangential acceleration.





Torque

- Consider a point particle under the influence of a force $\vec{\mathbf{F}}$, how is Newton's second law modified?
  - First must define a coordinate system, since the torque depends on where the origin is chosen. (If motion is circular or there is a symmetry point select the symmetry point, if there is a fixed point (hinge) select the fixed point.)



Newton's second law: $\vec{\mathbf{F}} = m\vec{\mathbf{a}}$

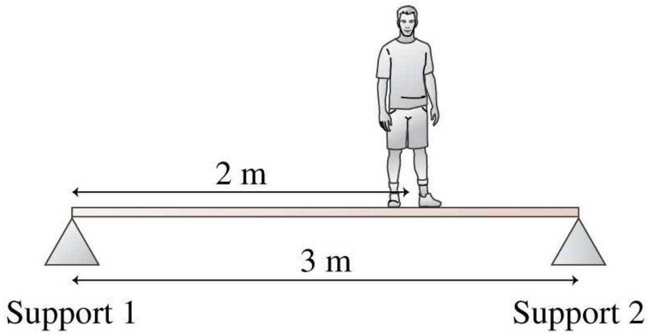
Take tangential components & multiply by r: $rF\sin\phi = mra_t = mr^2\alpha$

If multiple forces act on the system, then $\sum\tau = mr^2\alpha$

mr^2 is the moment of inertia, to be defined for an extended object later.

Example

A 3 m long rigid beam with a mass of $M = 100$ kg is supported at each end. An $m = 80$ kg student stands 2 m from support 1. How much upward force does each support exert on the beam?



Newton's second law forces:

$$n_1 + n_2 - mg - Mg = 0$$

Newton's second law torques:

$$n_2(3\text{ m}) - Mg(1.5\text{ m}) - mg(2\text{ m}) = 0$$

Do algebra

$n_1 = 751.3$ N and $n_2 = 1012.7$ N

Assignment

Continue reading chapter 13

Will discuss angular momentum and moments of inertia