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

Experience tells us \( \vec{F}_1 \) makes opening the door easier, assuming that all forces have the same magnitude. Force furthest from hinge and perpendicular causes largest acceleration.
Define torque $\tau = r F_\perp = r F\sin\phi$ $F_\perp$ is the component of the force that gives the tangential acceleration.
Consider a point particle under the influence of a force $\vec{F}$, 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: $\vec{F} = ma$

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

$$n_1 = 751.3 \text{ N and } n_2 = 1012.7 \text{ N}$$
Continue reading chapter 13

Will discuss angular momentum and moments of inertia