Fri: HW by 5pm

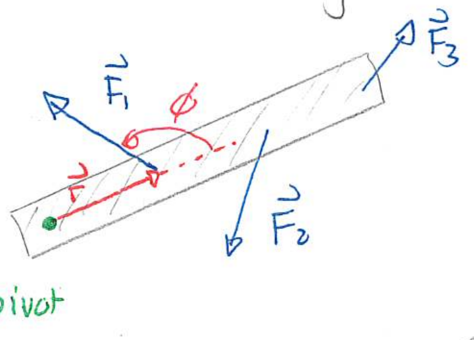
Ex 365, 368, 370, 372, 373, 375, 377, 378

Mon: Warm Up 14 by 9am

Torque

The rotational effects of forces can be described using torque

Forces act on object



→ Torque produced by force $\vec{F}$ about pivot O is

$$\tau = rF\sin\phi$$

where r = distance from pivot to $\vec{F}$

F = magnitude of force

ϕ = angle measure c.c.w from pivot force line

→ Net torque on an object is

$$\tau_{net} = \tau_1 + \tau_2 + \ldots = \sum_{\text{all forces}} \tau_i$$

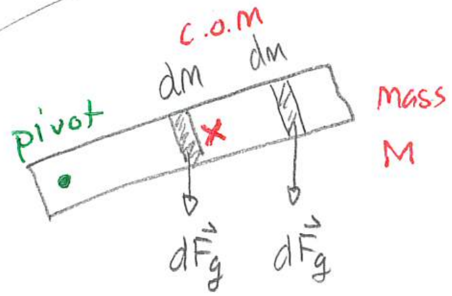
where τ_i is the torque produced by $\vec{F}_i$.

→ Net torque determines angular acceleration

→ Forces will change rotational state of motion ⇒ forces produce angular acceleration.

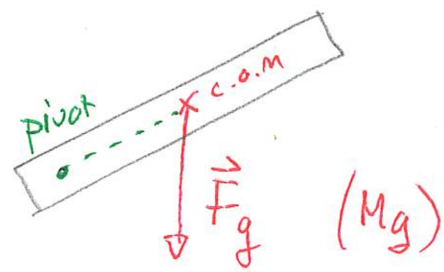
Warm Up 1 (from per previous)

For extended objects, there will be a gravitational force on the object. This results from the gravitational forces exerted on every small portion of the object. We have



Each small gravitational force produces a small torque.

→ The net torque produced by the gravitational forces is the same as a single torque produced by one gravitational force acting at the center-of-mass



Quiz 1 65% {40%-50%

Equilibrium

An object is in static equilibrium if it is either:

1) at rest or
2) moves with constant linear velocity AND constant angular velocity.

In this case

An object is in static equilibrium $\Leftrightarrow$ $\vec{F}_{net} = 0$ and $\tau_{net} = 0$

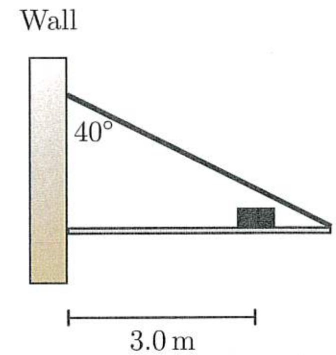
Fundamental Mechanics: Group Exercise 8

13 November 2024

Names: ________________ ________________ ________________ ________________ ________________

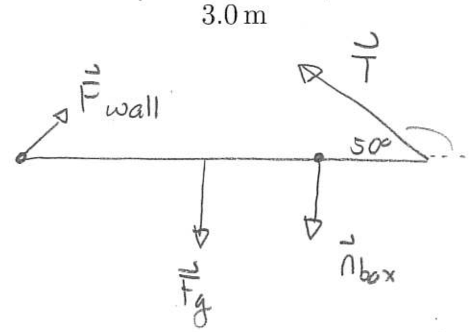
1 Beam perpendicular to a wall

A 4.0 m long, 80 kg beam is anchored to a wall and held at rest horizontally by a rope at the illustrated angle. The thickness of the beam is negligible. A 10 kg box rests on the beam at the illustrated point. Determine the tension in the rope in the illustrated situation, using the conditions for equilibrium. Will a rope with breaking strength 650 N manage to support the beam in this situation?



$\tau_{net} = 0$

$\Rightarrow \tau_{wall} + \tau_g + \tau_{box} + \tau_{rope} = 0.$



In all cases $\tau = rF\sin\phi$

Rope: $\phi = 180° - 50° = 130°$ $\quad \tau_{rope} = rF\sin 130°$

$= 4.0\,m\, T\sin 130° = 3.06\,m\, T$

Box: $\phi = 270°$ $\quad \tau_{box} = rF\sin 270°$

$F = M_{box}\, g$

$= 3.0\,m \times 10\,kg \times 9.8\,m/s^2 (-1) = -294\,Nm$

Gravity $\phi = 270°$ $\quad \tau_{grav} = rF\sin 270°$

$F = M_{beam}\, g$

$= 2.0\,m \times 80\,kg \times 9.8\,m/s^2 (-1) = -1570\,Nm$

Wall $r = 0$ so $\tau = rF_{wall}\sin\phi = 0\,N{\cdot}m$.

Thus: $\tau_{wall} + \tau_g + \tau_{box} + \tau_{rope} = 0$

$\Rightarrow 3.06m\,T - 294NM - 1570NM = 0$

$\Rightarrow 3.06m\,T = 1867N{\cdot}M$

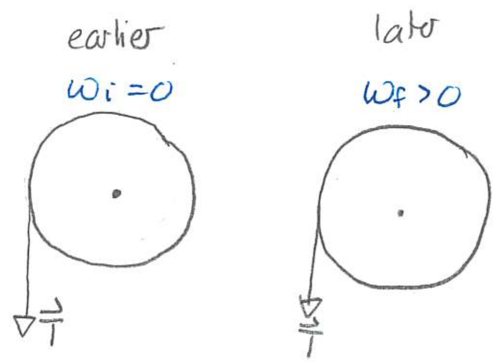
$\Rightarrow T = 610\,N$

The rope will be able to support the beam

Torque and dynamics

In general torques tend to produce angular acceleration. So we ask.

Given particular torques acting on an object what is the angular acceleration?



We can answer this via:

Form the net torque τ_{net}

$$\alpha = \frac{\Delta\omega}{\Delta t} \neq 0.$$

↳ The angular acceleration α is proportional to the net torque.

↳ More precisely

$$\tau_{net} = I\alpha$$

where the quantity I depends on the arrangement of the rotating mass and is called the moment of inertia

Quiz 2 10% — } 30%

Quiz 3

We will now seek to make the moment of inertia more precise.