Thurs HW by 5pm TURN-IN

Ex 284, 286, 287ab, 292, 293, 299, 301, 302

Fri: Review Exam III

Covers: Ch 9; 10, 7, 8.1 Energy, momentum, rotational motion.

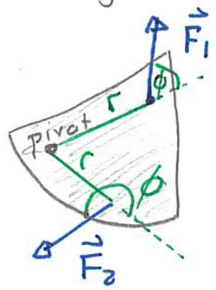
2016 Exam III All Questions except 6b

2019 Exam III All Questions

Rotational dynamics.

The scheme for assessing rotational motion is:

Specify forces acting on an object and a pivot.



→ Determine torque produced by each force

$\tau = rF\sin\phi$

→ Determine net torque

$\tau_{net} = \tau_1 + \tau_2 + \ldots$ (add each torque produced by each force)

→ Find moment of inertia of object, I. Various ways to determine/look up

→ Determine angular acceleration using

$\tau_{net} = I\alpha$

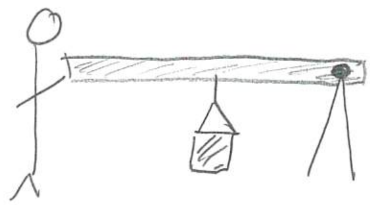
Warm Up 1

Equilibrium

An object is in equilibrium if both its velocity and angular velocity are constant. A common example of this is an object that is at rest and does not rotate. In this case

$$\vec{F}_{net} = 0 \quad \text{AND} \quad \tau_{net} = 0 \quad \text{Equilibrium}$$

Warm Up 2



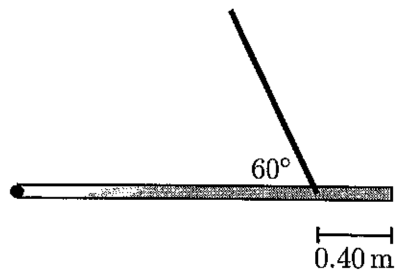
DEMO: Google Images of Forearm equilibrium

This applies to:

1) human physiology
2) structures in buildings
3) people in traction.

1 Beam in equilibrium

A 10 kg beam with length 2.0 m can pivot about its left end. A rope is attached as illustrated. The thickness of the beam is negligible.



a) State the conditions for equilibrium.

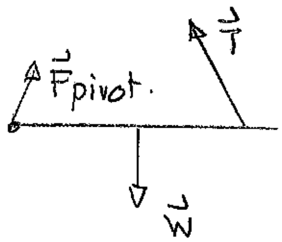
b) Draw all the force vectors on the beam.

c) Identify a pivot point (there are many correct possibilities – one is much more useful than the others) and determine expressions for the torque exerted by each force about the pivot.

d) Substitute the individual torques into one of the conditions for equilibrium and determine the tension in the rope.

Answer: a) $\tau_{net} = 0$ $\qquad \vec{F}_{net} = 0$

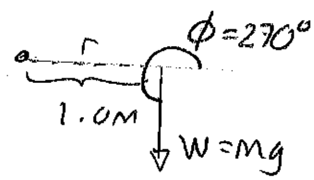
b)



c) left end.

pivot $\quad \tau_{pivot} = \cancel{r}^{\,0} F_{pivot} \sin\phi = 0\,\text{N}\cdot\text{m}$

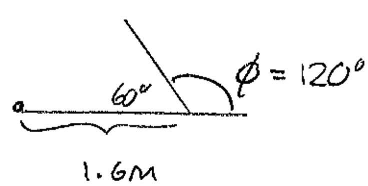
gravity $\quad \tau_{grav} = r F \sin\phi = r mg$



$= 1.0\,\text{m} \times 10\,\text{kg} \times 9.8\,\text{m/s}^2 \sin 270°$

$= -98\,\text{N}\cdot\text{m}$

rope $\quad \tau_{rope} = r F \sin\phi$



$= 1.6\,\text{m}\, T \sin 120°$

$= 1.39\,\text{m}\, T$

d) $\tau_{net} = 0 \Rightarrow \tau_{pivot} + \tau_{grav} + \tau_{rope} = 0$

$\Rightarrow 0\,\text{N}\cdot\text{m} - 98\,\text{N}\cdot\text{m} + 1.39\,\text{m}\,T = 0$

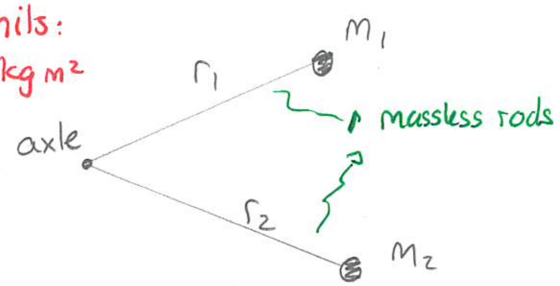
$\Rightarrow 1.39\,\text{m}\,T = 98\,\text{N}\cdot\text{m} \Rightarrow T = \dfrac{98\,\text{N}\cdot\text{m}}{1.39\,\text{m}} = 71\,\text{N}$

Moment of Inertia

In equilibrium situations, the moment of inertia is irrelevant. However, it will be important in non-equilibrium situations. The moment of inertia is first defined for point masses via

$$I = m_1 r_1^2 + m_2 r_2^2 + \dots \quad \text{(all masses)}$$

units: $kg\,m^2$

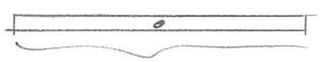


where m_i is the mass of object i

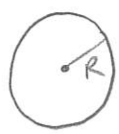
and r_i is the distance from the pivot.

This can be extended to continuously distributed masses and these can be calculated using techniques from calculus. Table 7.1 gives some results.

rod, pivot at end $\quad I = \frac{1}{3} M L^2$



rod, pivot at center $\quad I = \frac{1}{12} M L^2$



disk, about center $\quad I = \frac{1}{2} M R^2$

Quiz 1

Demo: Red / blue sticks