Torque Practice #1

$$\omega = \frac{\Delta\theta}{t} \qquad \alpha = \frac{\Delta\omega}{t} \qquad \Delta\theta = \frac{\Delta x}{r} \qquad \omega = \frac{v}{r} \qquad \omega = \frac{2\pi}{T} \qquad \alpha = \frac{a_t}{r} \qquad a_c = \frac{v^2}{r} = \omega^2 r$$

$$v = \frac{2\pi r}{T} \qquad \omega_f = \omega_0 + \alpha t \qquad \Delta\theta = \tfrac{1}{2}(\omega_0 + \omega_f)t \qquad \Delta\theta = \omega_0 t + \tfrac{1}{2}\alpha t^2 \qquad \omega_f^2 = \omega_0^2 + 2\alpha\Delta\theta \qquad T = \frac{1}{f} \qquad \tau = F_\perp r_\perp$$

1. A force of 20 N is applied perpendicular to the end of a bar of length 0.5 m. Calculate the torque produced by the force. ***10 Nm***

2. A child of mass 20 kg is located 2.5 m from the fulcrum or pivot point of a seesaw. Where must a child of mass 30 kg sit on the seesaw in order to provide balance? ***1.67 m***

3. Two girls are sitting on the same side of a see-saw. One girl is 28 kg and sitting 2.4 m away from the middle. The other girl is 35 kg and 2.6 m away from the middle. Their dad can balance them out if he sits 2.0 m away from the middle on the other side. What is their dad's mass? ***79.1 kg***

4. A fulcrum is placed under the center of a 5 m long rod. If a 125 N mass is attached at one end of the rod, where should a 200 N force be placed in order for the rod to remain in rotational equilibrium. ***1.56 m***

5. A 6 m long massless beam is placed on a fulcrum. If a 20 kg child sits on one end, and a 15 kg child sits on the other, where should the fulcrum be placed so that rotational equilibrium is assured. ***2.57 m from the 20 kg end***

6. What is the net torque about the center of a 1.8 m long massless rod when a 5 kg mass is attached to the left end, and a 3 kg mass is attached to the other? ***17.64 Nm***

7. A 200 N force is applied at an angle of 45° above the horizontal to a 4 m long horizontal beam. What torque does this force exert on the beam? ***565.7 Nm***

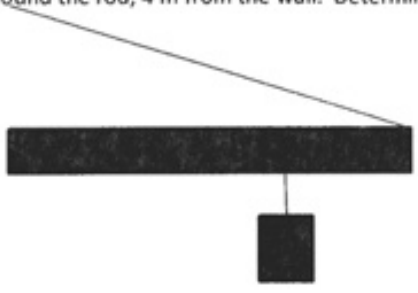
8. A 10 kg uniform plank of length L is pivoted about its center. A 4 kg mass is to be placed on the right end. How far from the pivot point must a 6 kg mass be placed to keep the plank in equilibrium? ***L/3 from the pivot point***

9. A 25 kg, 6 m long rod is attached at one end. Determine the torque associated with the rod due to its own weight if it were released from the other end. ***735 Nm***

10. From the previous question, a fulcrum is now placed 2 m from one end of the rod. Determine the torque associated with the rod due to its own weight if it were released. ***245 Nm***

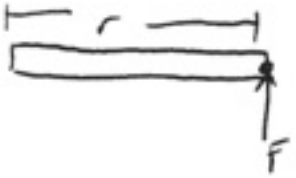
11. A boy and a girl have masses of 45 kg and 32 kg respectively. Both are balanced on opposite ends of a 5.0 m long wooden plank with a mass of 16 kg. At what point along the plank does the pivot point have to be? ***2.15 m from the 45 kg end***

12. A uniform rod of mass 12 kg and length 6 m is pivoted at one end to a wall and is partially supported by a guy wire attached at the free end, making a 30° angle with the horizontal. A 20 kg mass is suspended by a rope wrapped around the rod, 4 m from the wall. Determine the force of tension in the wire. ***379 N***



Torque Practice #1

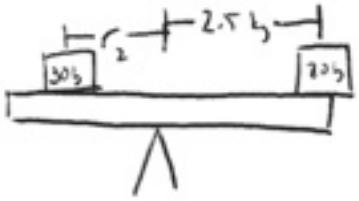
① $\tau = F \cdot r$



$\tau = (20\ N)(.5\ m)$

$\tau = 10\ N \cdot m$

②



$\Sigma \tau = \tau_1 - \tau_2 = 0$

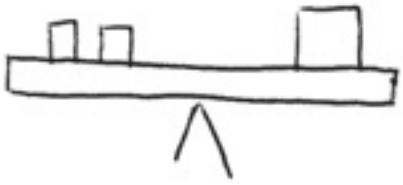
$F_1 \cdot r_1 = F_2 \cdot r_2$

$(m_1 g) r_1 = (m_2 g) r_2$

$(20\ kg) g (2.5\ m) = (30\ kg) g\ r_2$

$r_2 = 1.67\ m$

③



$\Sigma \tau = \tau_{Dad} - (\tau_1 + \tau_2) = 0$

$(m_{Dad} g) r_{Dad} = (m_1 g) r_1 + (m_2 g) r_2$

$(m_{Dad}) g (2\ m) = (28\ kg) g (2.4\ m) + (35\ kg) g (2.6\ m)$

$m_{Dad} = 79.1\ kg$

④

$\Sigma \tau = \tau_{125} - \tau_{200} = 0$

$F_{125} \cdot r_{125} = F_{200}\ r_{200}$

$(125\ N)(2.5\ m) = (200\ N)\ r_{200}$

$r_{200} = 1.56\ m$

⑤

$r_1 + r_2 = 6\,m$

$r_1 = 6\,m - r_2$

$\Sigma\tau: \tau_1 - \tau_2 = 0$

$(m_1 g) r_1 = (m_2 g) r_2$

$(20\,kg) g\, r_1 = (15\,kg) g\, r_2$

$(20\,kg)(6\,m - r_2) = (15\,kg) r_2$

$120\,kg\cdot m - (20\,kg) r_2 = (15\,kg) r_2$

$120\,kg\cdot m = (35\,kg) r_2$

$r_2 = 3.43\,m$

$r_1 = 2.57\,m$

⑥

$\Sigma\tau: \tau_5 - \tau_3 = \tau_{net}$

$F_5 r_5 - F_3 r_3 = \tau_{net}$

$(5\,kg) g (.9\,m) - (3\,kg) g (.9\,m) = \tau_{net}$

$\tau_{net} = 17.64\ N\cdot m$, CCW

⑦

$\tau = F_\perp r_\perp$

$\tau = (F \sin\theta)\, r$

$\tau = (200\,N \cdot \sin 45)(4\,m)$

$\tau = 565.7\ N\cdot m$

⑧

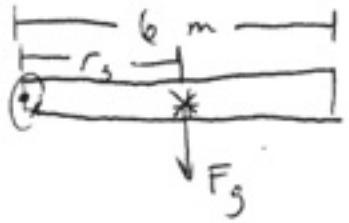
$\tau: \tau_1 - \tau_2 = 0$

$(m_1 g) r_1 = (m_2 g) r_2$

$(6\,kg) g\, r_1 = (4\,kg) g \left(\frac{L}{2}\right)$

$r_1 = \frac{L}{3}$

(9)

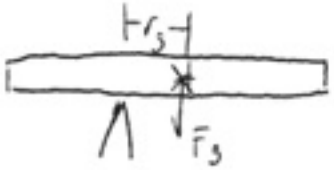


$\tau = F_g \cdot r_g$

$\tau = (25\,kg)g(3\,m)$

$\tau = 735\ N \cdot m$

(10)

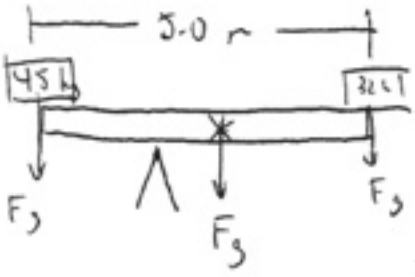


$\tau = F_g \cdot r_g$

$\tau = (25\,kg)g(1\,m)$

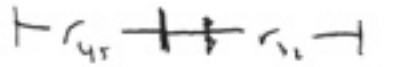
$\tau = 245\ N \cdot m$

(11)



$\Sigma\tau: \tau_{45} - (\tau_{32} + \tau_{16}) = 0$

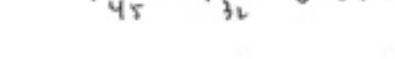
$\tau_{45} = \tau_{32} + \tau_{16}$



$F_{45} \cdot r_{45} = F_{32} r_{32} + F_{16} r_{16}$

$r_{45} + r_{32} = 5.0\,m$

$(45\,kg)g\, r_{45} = (32\,kg)g\, r_{32} + (16\,kg)g\, r_{16}$



$(45\,kg)(5.0\,m - r_{32}) = (32\,kg)r_{32} + (16\,kg)(r_{32} - 2.5\,m)$

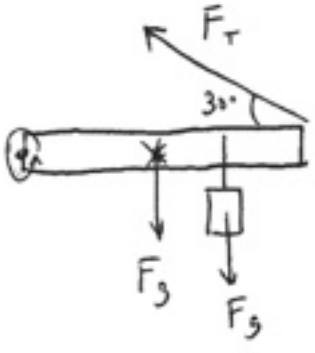
$r_{16} + 2.5\,m = r_{32}$

$225\ kg \cdot m - (45\,kg)r_{32} = (32\,kg)r_{32} + (16\,kg)r_{32} - 40\ kg \cdot m$

$265\ kg \cdot m = (93\,kg)r_{32}$

$r_{32} = 2.85\,m$

(12)



$\Sigma\tau: \tau_T - (\tau_{rd} + \tau_{mm}) = 0$

$F_{T_\perp} r_T = F_{rd} \cdot r_{rd} + F_{mm} \cdot r_{mm}$

$(F_T \sin 30)(6\,m) = (12\,kg)g(3\,m) + (20\,kg)g(4\,m)$

$F_T = 379\ N$