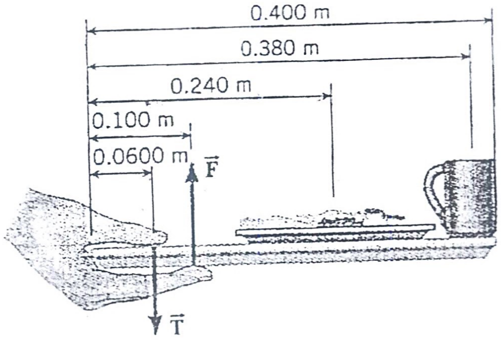
Rotational Dynamics Group Problems

1. Certain types of dinosaurs were bipedal. What is a good reason why such creatures invariably had long tails if they had long necks? Use a diagram to help explain.

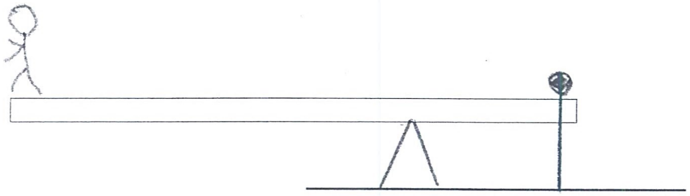
2. You must lean quite far forward as you rise from a chair (try it!). Explain why, with diagrams.

3. A lunch tray us being held in one hand, as shown. The mass of the tray itself is 0.20 kg and the tray is a regularly shaped object. One the tray is a 1.0 kg plate of food and a 0.25 kg cup of coffee. The tray is being held by the thumb and fingers, as shown. Both the thumb force and the finger force act perpendicular to the tray and the tray is parallel to the ground. Find the forces T and F.

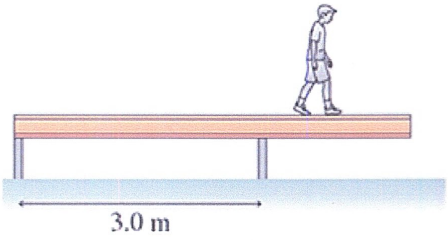


4. A person (w = 530 N) stands at the end of a massless diving board. The diving board rests on a support and is prevented from bouncing at the ground end by a bolt, as shown. The diving board is 3.9 m long, and the support is 1.4 m from the bolted end. Find

   a. the force which the support exerts on the board.
   b. the force which the bolt exerts on the board.

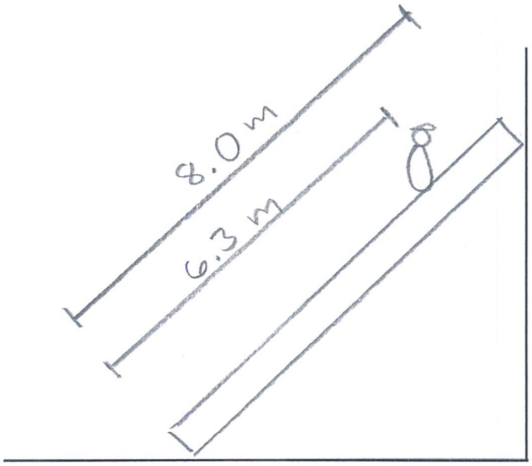


5. A 40 kg, 5.0 m long beam is supported by, but not attached to, the two posts shown. A 20 kg boy starts walking along the beam. How close can he get to the right end of the beam without it tipping?

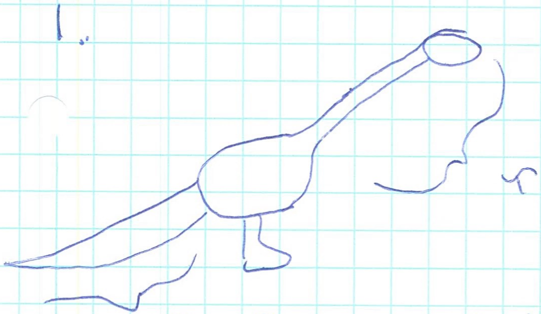


6. An 8.0 m long ladder (weight = 355 N) rests against a frictionless vertical wall, and makes an angle of 50^0 with the ground. A firefighter, whose weigh is 875 N, stands 6.3 m along the ladder. Treat the ladder as a regularly shaped object.

a. draw all the forces acting on the ladder.
b. find the magnitude of each of these forces.



1.

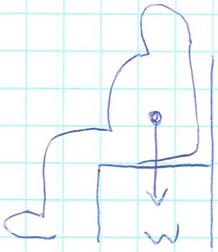


To be balanced, must keep CG over feet.

τ from weight of head & neck

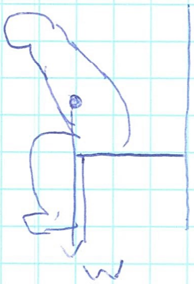
τ from weight of tail helps keep $\Sigma\tau = 0$ around feet.
Or, helps keep CG over feet.

2.



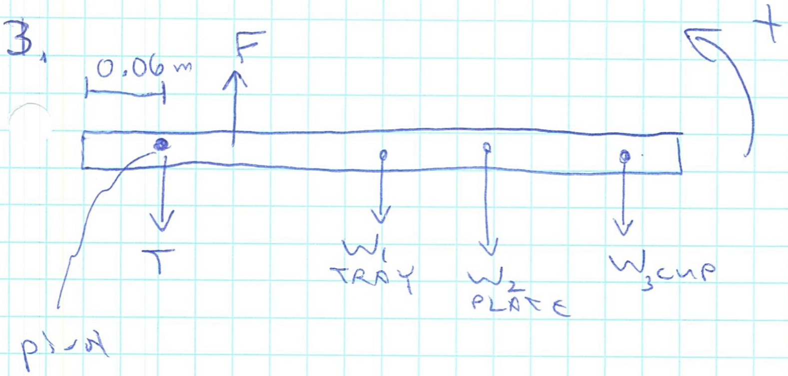
Your CG is in abdomen.

Once you start to rise, your weight acting at CG creates a τ which pulls you back toward seat of chair.



If you lean forward, you can get your CG over your feet to keep balanced as you rise.

3.



All distances are known.

I pick pivot at Thumb.

All angle φ are 90°, so $\sin\varphi = 1$ for all.

$$\Sigma \tau = I\alpha$$

$$(Fr)_F - (W_1 r)_{TRAY} - (W_2 r)_{PLATE} - (W_3 r)_{CUP} = 0$$

$$F(0.1 - 0.06\text{ m}) - (0.20\text{ kg})(9.8\text{ m/s}^2)(0.2 - 0.06\text{ m})$$
$$- (1.0\text{ kg})(9.8\text{ m/s}^2)(0.24 - 0.06\text{ m}) -$$
$$(0.25\text{ kg})(9.8\text{ m/s}^2)(0.38 - 0.06\text{ m}) = 0$$

$$F(0.04) - 0.2744 - 1.764 - 0.784 = 0$$

$$F = 70.6\text{ N}$$

now:
up + for Newton's

$$\Sigma F = ma$$

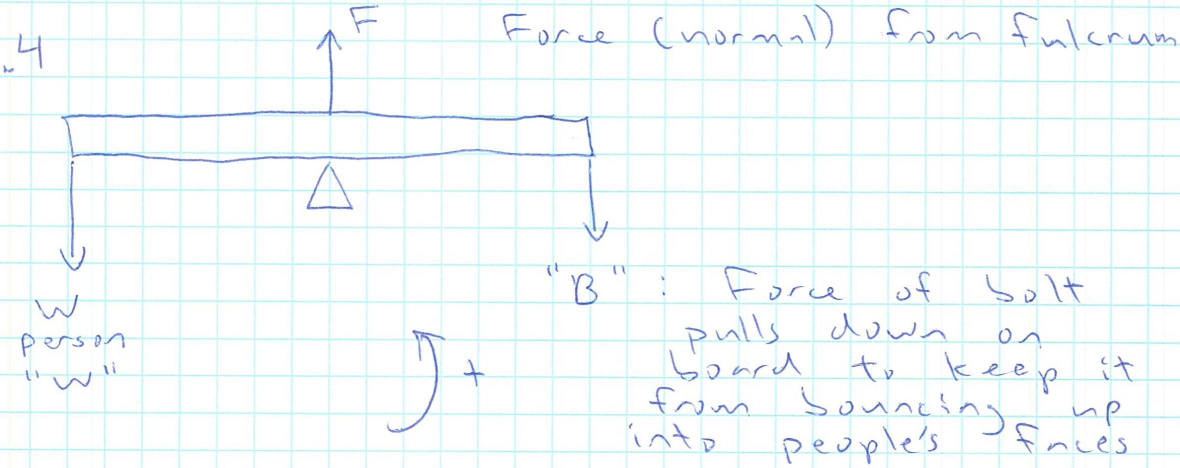
$$F - T - W_1 - W_2 - W_3 = 0$$

$$T = 70.6 - 1.96 - 9.8 - 2.45$$

$$T = 56.4\text{ N}$$

or pick a different pivot and sum τ again

2.4



Force (normal) from fulcrum

"B" : Force of bolt pulls down on board to keep it from bouncing up into people's faces

I pick axis at Bolt:

$$\Sigma \tau = I\alpha$$

$$(W r \sin\varphi)_{PERSON} - (F r \sin\varphi)_{FULCRUM} = 0$$

$$(530\ N)(3.9\ m)\sin 90^\circ - F(1.4\ m)\sin 90^\circ = 0$$

$$1.4F = 2067$$

$$F = 1476\ N$$

Second axis pick at Fulcrum.

$$(W r \sin\varphi)_{PERSON} - (B r \sin\varphi)_{BOLT} = 0$$

$$(530\ N)(2.5\ m)\sin 90^\circ = B(1.4\ m)\sin 90^\circ$$

$$B = 946$$

Check with $\Sigma F = ma$:

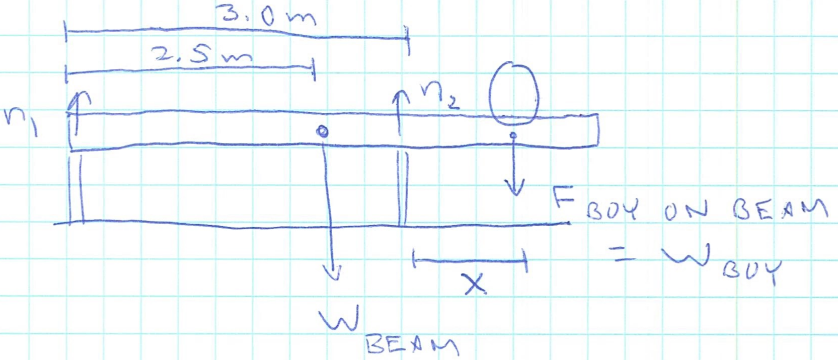
$$F - W - B = ma$$

$$1476 - 530 - 946 = ma$$

$$0 = ma$$ ✓ Not accelerating!

8-49

(5)

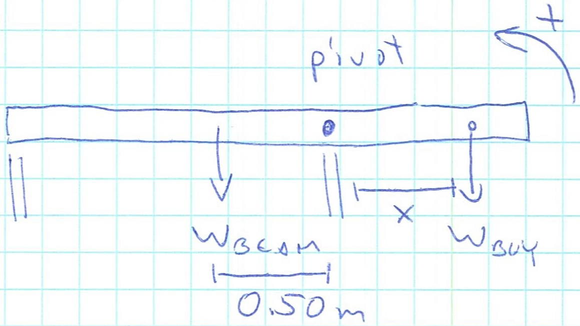


Want to find x when beam is just about to tip: this will be furthest out boy can stand.

Remember your meter stick on table - when it is about to tip, it really is only making contact at the tipping point.

Here, that means $n_1 = 0$ when at max distance.

I choose pivot at n_2.



$\tau_{n2} = 0$

$n_1 = 0$ so $\tau_{n1} = 0$

$\Sigma \tau = I\alpha$

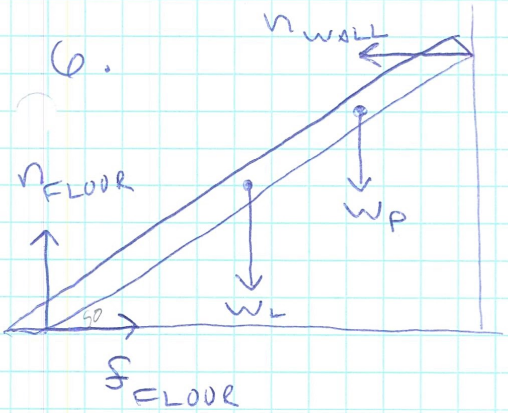
$(Wr\sin\theta)_{BEAM} - (Wr\sin\theta)_{BOY} = 0$

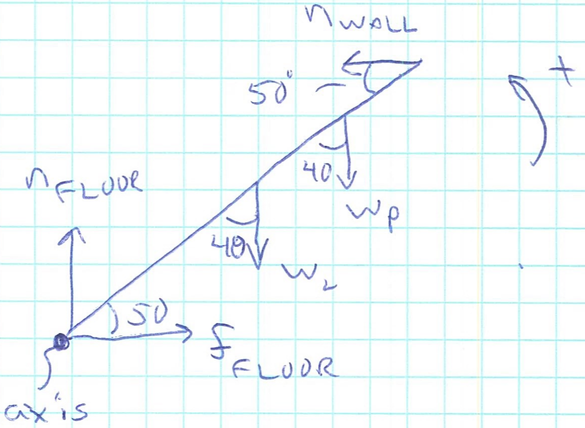
$(m\cancel{g}r\sin 90°)_{BEAM} = (m\cancel{g}r\sin 90°)_{BOY}$

$(40\text{ kg})(0.5\text{ m}) = (20\text{ kg})\,x$

$x = 1.0\text{ m}$

6.





Around my pivot: $$\left.\begin{array}{l}\tau_{nFLOOR} = 0\\ \tau_{fFLOOR} = 0\end{array}\right\} r = 0$$

$$\tau_F = F r \sin\varphi$$

$$\tau_{WL} = (W_L) r_L \sin\varphi_L = (355)(4.0)\sin 40^\circ$$

$$\tau_{WP} = (W_p) r_p \sin\varphi_p = (875)(6.3)\sin 40^\circ$$

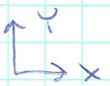
$$\tau_{nwall} = (n_w) r_n \sin\varphi_n = n(8.0)\sin 50^\circ$$

$$\Sigma\tau = I\alpha$$

$$-(355)(4)\sin 40 + -875(6.3)\sin 40 + n(8)\sin 50 = 0$$

$$n_{WALL} = 727 \text{ N}$$

$$\Sigma F_x = ma_x$$



$$\Sigma F_Y = ma_Y$$

$$f_{FLOOR} - n_{WALL} = 0$$

$$f_{FLOOR} = n_{WALL} = 727 \text{ N}$$

$$n_{FLOOR} - W_L - W_p = 0$$

$$n_{FLOOR} = W_L + W_p = 355 + 875 \text{ N} = 1230 \text{ N}$$