Physics 2A: Lecture 14

CH12

Today's Agenda

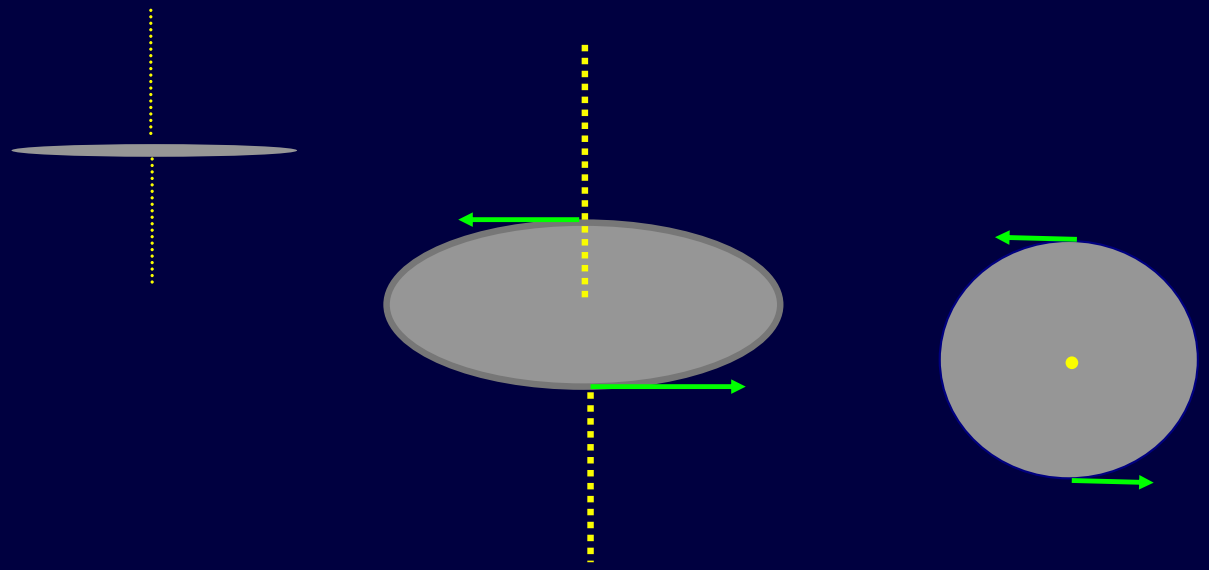
- Rotational dynamics
  - Kinetic Energy
  - Moment of Inertia
  - Torque
  - Newton's Second Law for Rotations

Review: Equations for Rotational Kinematics

- We had x position now we have θ
- We had v velocity now we have ω
- We had a acceleration now we have α
- Linear equations of kinematics:
  - $\theta_F = \omega_0 t + \frac{1}{2}\alpha t^2$
  - $\omega_F = \omega_0 + \alpha t$
  - $\omega_F^2 = \omega_0^2 + 2\alpha\Delta\theta$
  - Good when acceleration = constant

Axis of Rotation

- Axis of Rotation: The line which things rotate about.

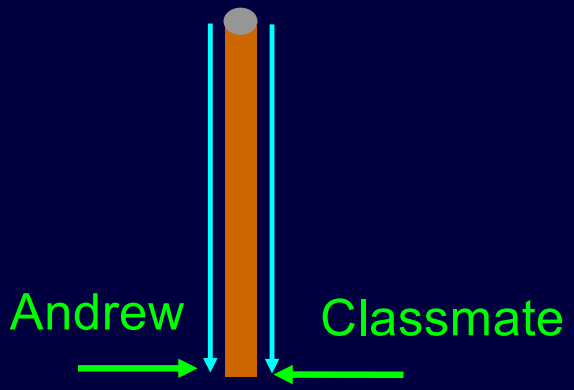


Example with a door

- Lets try something

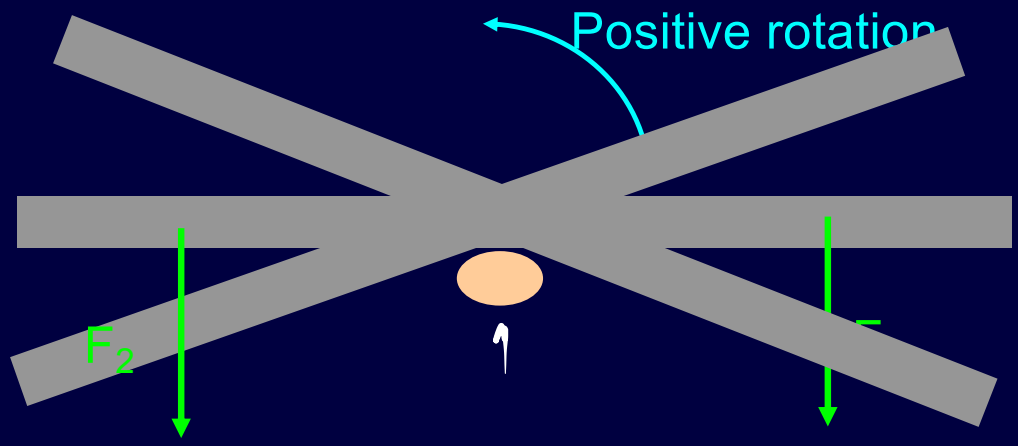
Rotational force depends on where it acts

Further from axis of rotation, stronger rotational force!



Positive vs. Negative torque

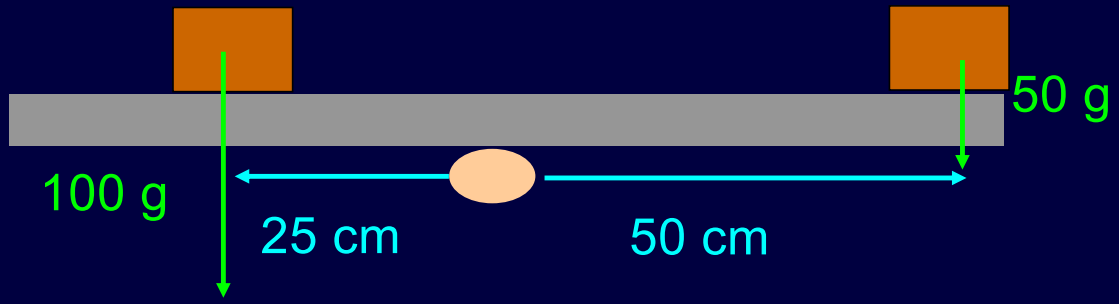
- Torque can be positive or negative
- Call counterclockwise positive rotation



- F_1 wants to rotate negative; F_2 positive

Ruler Demo

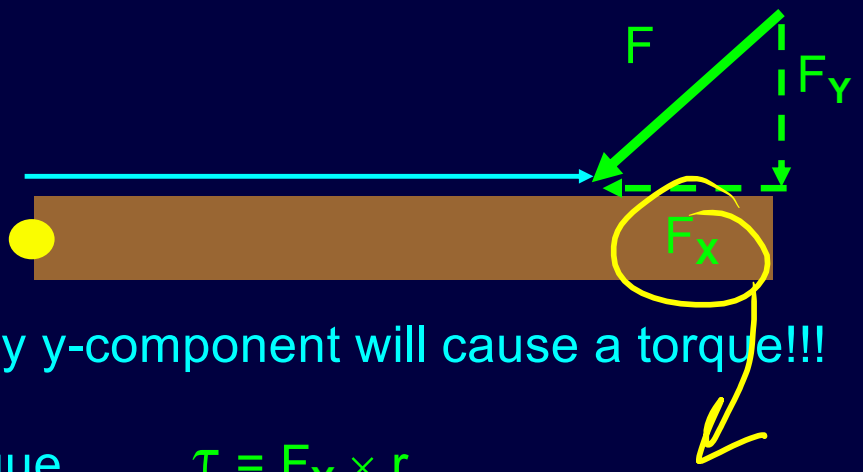
- Ruler can rotate around my finger
- $\tau = F \times r$



- The two torques cancel out!!

Torque

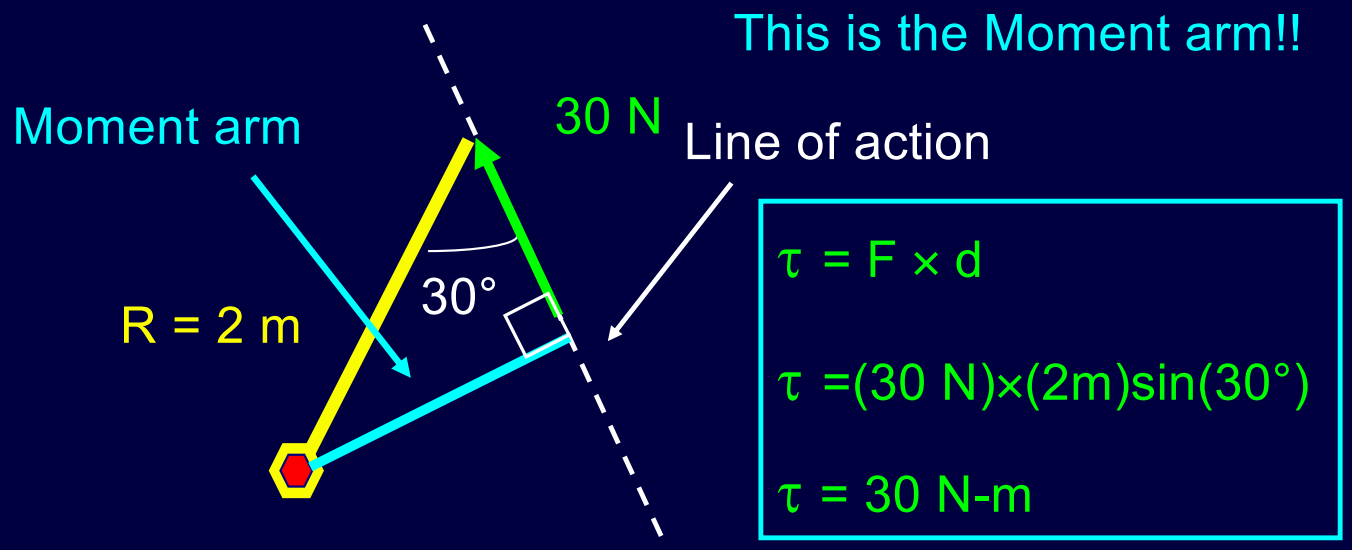
- Sometimes only part of a force causes a torque



- Only y-component will cause a torque!!!
- Torque $\tau = F_Y \times r$

Finding the Moment arm

- Draw the line of action
- Line of action: line through force to infinity
- Now connect the axis of rotation with line of action with the shortest line possible



$\tau = F \times d$

$\tau = (30\ N) \times (2m) \sin(30°)$

$\tau = 30\ N\text{-}m$

Length that is perpendicular to force!!

Clicker Question 1:

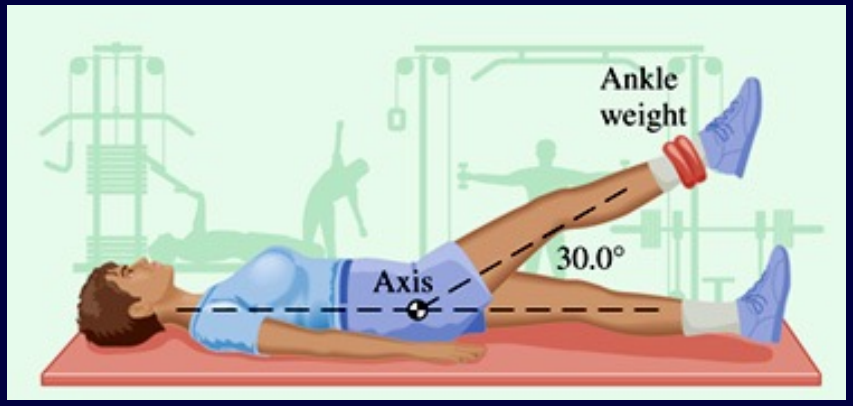
A person raises one leg to an angle of 30 degrees. An ankle weight (89 N) attached a distance of 0.84 m from her hip. What is the torque due to this weight?

(a) 65 Nm

(b) 37.3 Nm

(c) 74.8 Nm

(d) 0 Nm



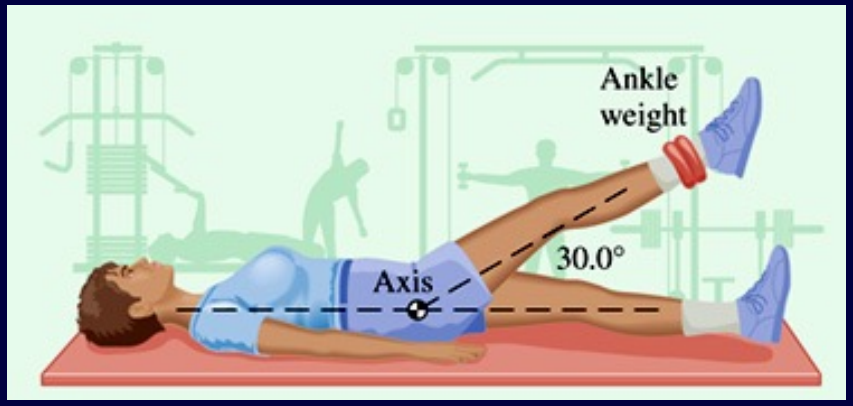
Clicker Question 2:

If she raises her leg higher, the torque due to the weight will

A) Increase

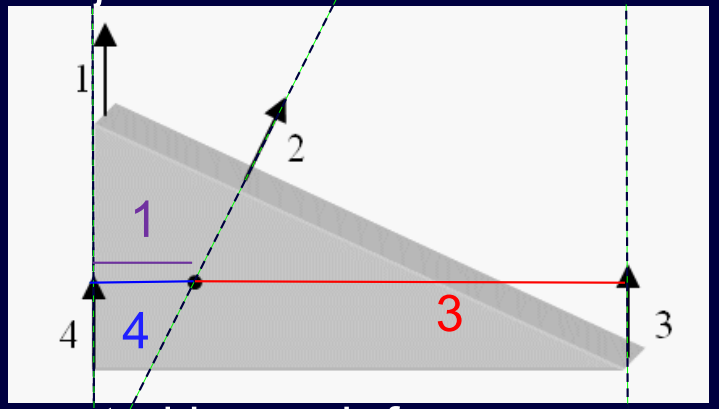
B) Same

C) Decrease



Clicker Question 3:

An object with a triangular cross-section is free to rotate about the axis represented by the black dot shown. Four forces with identical magnitudes are exerted on the object. Which one of the forces, if any, exerts the largest torque on the object?



a) 1
b) 2
c) 3
d) 4
e) The same torque is exerted by each force.

Static Equilibrium

- An object is in static equilibrium if all the forces and torques acting on it sum to zero

- $\Sigma F_X = 0$ and $\Sigma F_Y = 0$
- As well $\Sigma \tau = 0$

- $\Sigma \tau = 0$ works about ANY axis! Otherwise it would rotate about that axis. You get to choose the axis. Choose where the most forces act, or where forces you are not interested in are acting.

- We will learn to apply these laws to problems and solve for various unknowns

Solving Static Equilibrium Problems

Step 1: What forces are acting on our object?

Step 2: Draw a Free Body Diagram for each object.

Step 3: Select coordinate system.

Try to get as many forces in x-y direction

Step 4: Break all forces into x-y components

Step 5: Apply Newton's Second law.

$\Sigma F_X = 0$

$\Sigma F_Y = 0$

$\Sigma \tau = 0$

Step 6: Solve for what you need.

Static Equilibrium

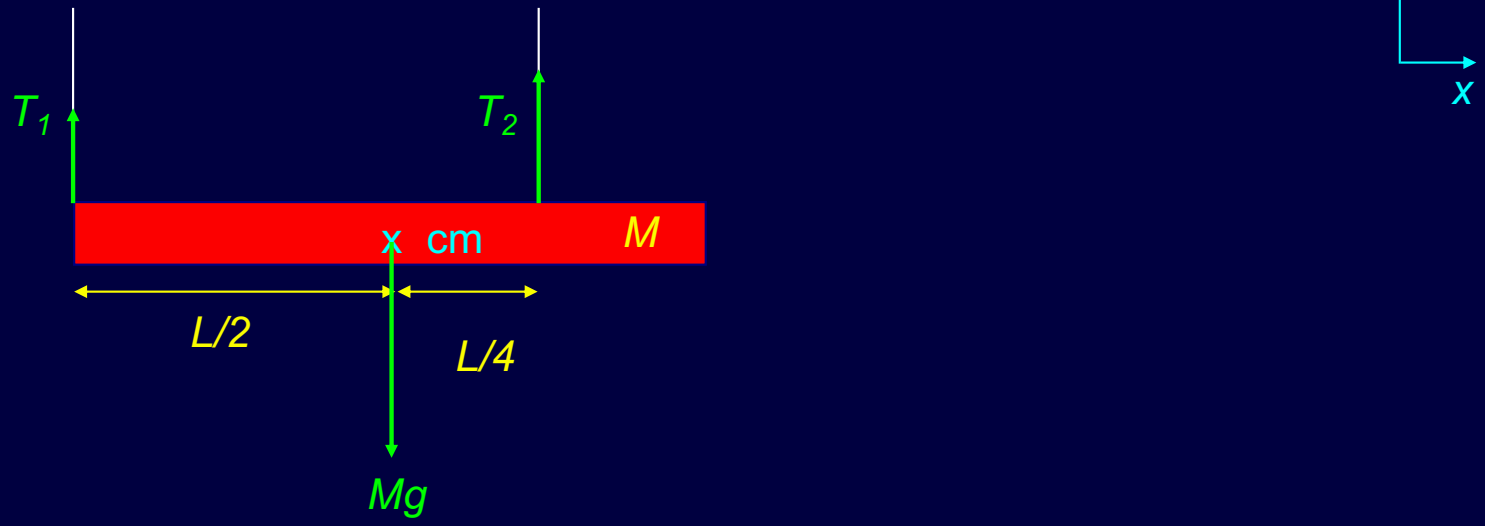
- I like to think of it as the positive torques must equal the negative torques

- $\tau_{positive} = \tau_{negative}$

- $F_{positive} = F_{negative}$

Using Torque:

- Here is a hanging planck of mass 30 kg and length 2 m. Find the two tensions. Torque is a vector pointing in/out of page

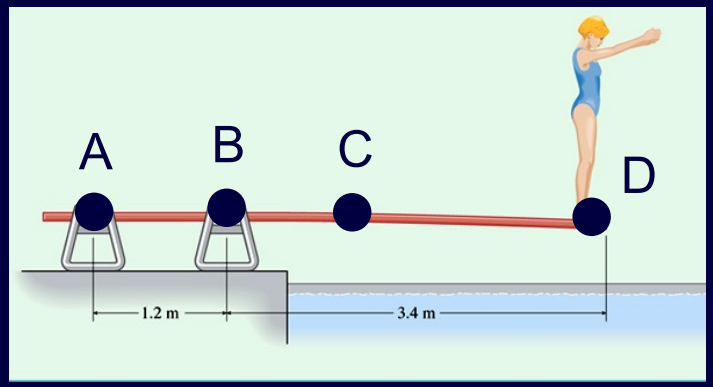


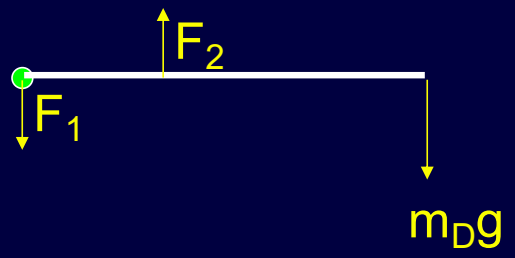
$T_1 = 98$ N

$T_2 = 196$ N

Clicker Question 4:

A 50 kg diver stands at the end of a 4.6 m diving board. Where is the best place to put your rotational axis if you want to find the force on the pivot at point B? (Neglect the mass of the diving board)





Clicker Question 5:

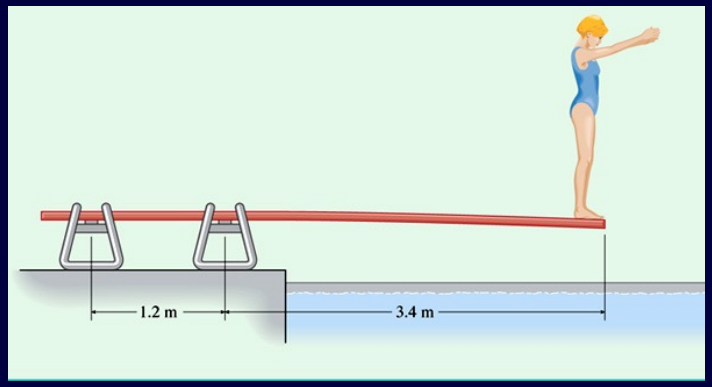
A 50 kg diver stands at the end of a 4.6 m diving board. Neglecting the weight of the board, what is the force on the pivot 1.2 meters from the end?

(a) 1880 N

(b) 613.1 N

(c) 1330 N

(d) 813.7 N



Clicker Question 6:

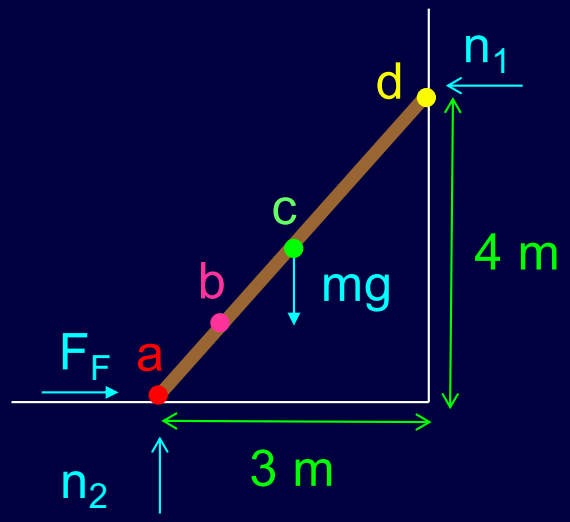
A ladder of mass 10 kg and length 5 m leans against a smooth wall. What is the best spot for the axis of rotation? (Suppose out goal is to solve for all forces)

(a)

(b)

(c)

(d)



Clicker Question 7:

A ladder of mass 10 kg and length 5 m leans against a wall. Assume the floor is rough, and the wall is smooth. Which $\tau_{positive} = \tau_{negative}$ is correct about the red axis?

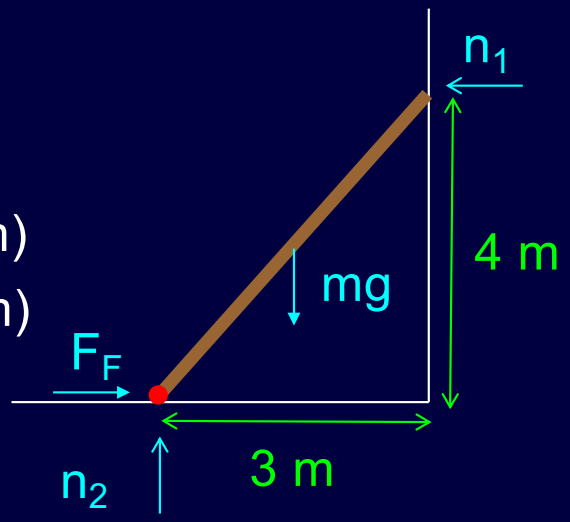
(a) $n_1(3\ m) = mg\ (4\ m)$

(b) $n_1(4\ m) = mg\ (3\ m)$

(c) $n_2(3\ m) = mg\ (1.5\ m)$

(d) $n_1(4\ m) = mg\ (1.5\ m)$

(e) $n_2(3\ m) = mg\ (3\ m)$



Clicker Question 8:

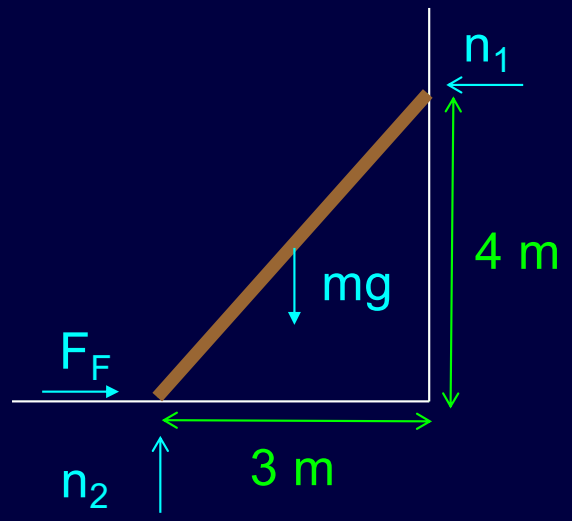
A ladder of mass 10 kg and length 5 m leans against a wall. Assume the floor is rough, and the wall is smooth. What must the other forces be?

(a) $n_2 = 36.8$ N, $F_F = 36.8$ N

(b) $n_2 = 36.8$ N, $F_F = 98$ N

(c) $n_2 = 98$ N, $F_F = 36.8$ N

(d) $n_2 = 98$ N, $F_F = 98$ N



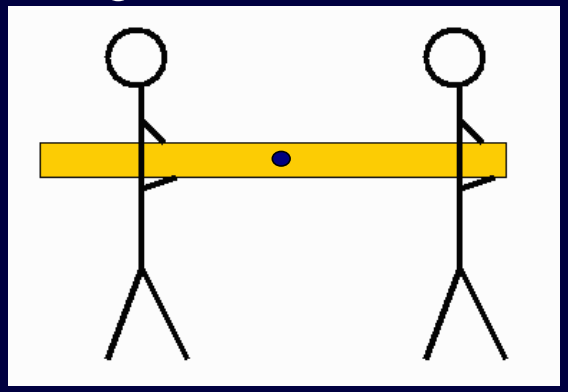
Clicker Question 9:

The picture below shows two people lifting a heavy log.
Which of the two people is supporting the greatest weight?

A. The person on the left is supporting the greatest weight

B. The person on the right is supporting the greatest weight

C. They are supporting the same weight



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