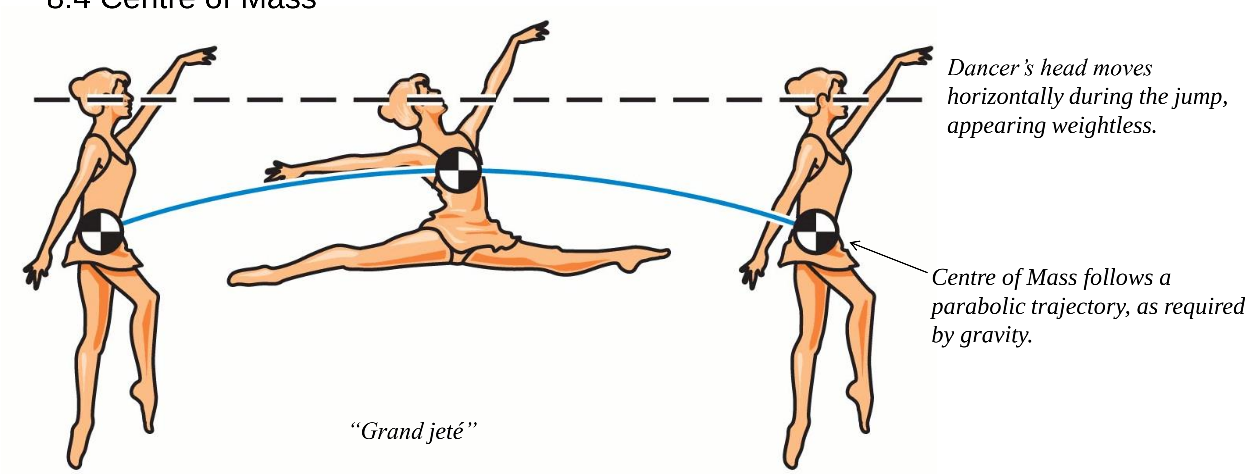
PHY131H1F - Class 24

Today:

8.3 Static Equilibrium

8.4 Centre of Mass

+ Ch.5-7 Review



http://www.chegg.com/homework-help/questions-and-answers/grand-jete-classic-ballet-manoeuvre-dancer-executes-horizontal-leap-moving-arms-legs--cent-q5975347

1

Poll

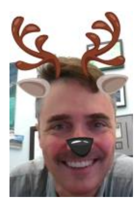
Crazy Friday: Let's Choose a Zoom-Filter my face today

What Studio Filter would you prefer on my face today?

A. Happy Sprout 

B. Pizza on Head 

C. Shades 

D. Reindeer antlers 

E. Bunny rabbit 

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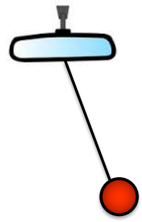
Ch.7 Review

Poll Question

- A string is attached to the rear-view mirror of a car. A ball is hanging on the other end of the string. The car is turning left on a smooth horizontal circle, at a **constant speed**. What direction is the ball accelerating?



A. Up
B. Horizontal to the left
C. Horizontal to the right
D. Diagonally up & to the left
E. Diagonally up & to the right
F. The ball is not accelerating

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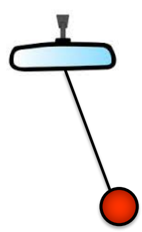
Ch.7 Review

Poll Question

- A string is attached to the rear-view mirror of a car. A ball is hanging on the other end of the string. The car is turning left on a smooth horizontal circle, at a constant speed. Which of the following lists gives all of the forces directly acting on the ball?



A. Tension
B. Tension, gravity, the centripetal force and friction
C. Tension and gravity
D. Tension, gravity and the centripetal force

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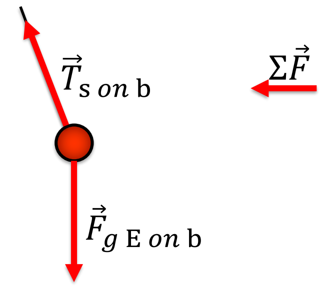
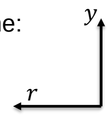
Ch.7 Review

- Centripetal Force **is** the Net force on an object moving in uniform circular motion!
- This net force is the vector sum of all the actual forces on the free body diagram.
- You do NOT draw centripetal force as an extra force acting on the object.



Define:



$$a_r = \frac{\Sigma F_r}{m} = \frac{v^2}{r}$$

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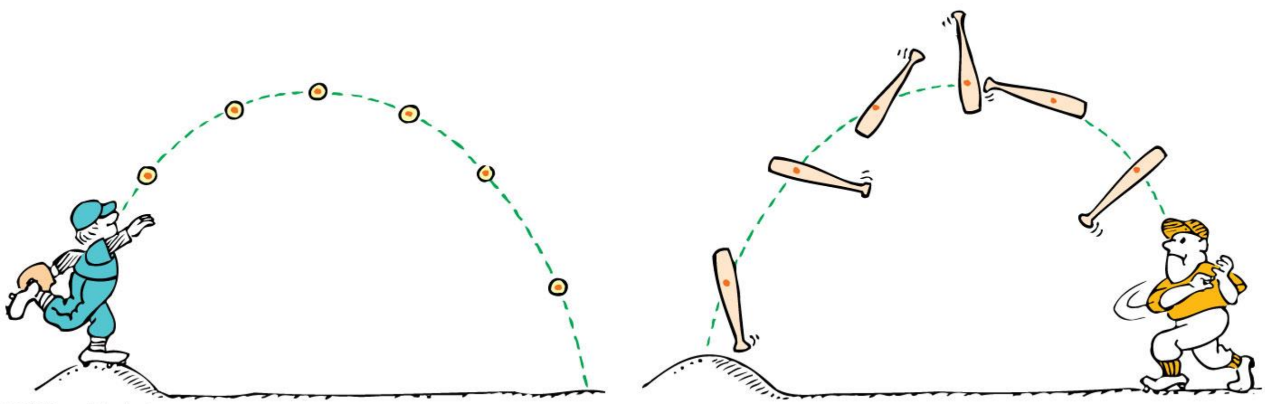
- **Centre of mass** is the average position of all the mass that makes up the object.
- **Centre of gravity (CG)** is the average position of weight distribution.
  - Since here on Earth weight and mass are proportional, centre of gravity and centre of mass always refer to the same point of an object.



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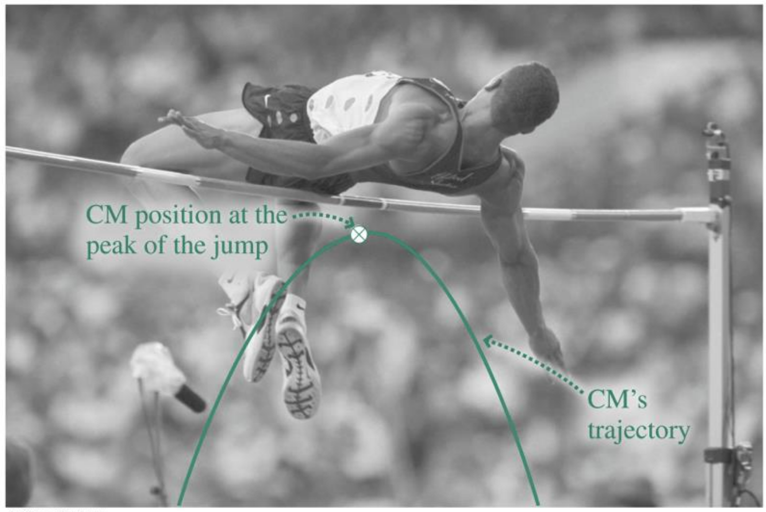
- How is it possible to clear the bar in a high jump if your center of mass does not reach to the height of the bar?
- ANSWER:



- For a projectile, the motion of the centre of mass is governed by the equations of constant acceleration we already know.
- The center of mass of a complicated shape (like a person doing a back arch) does not need to be within the object.

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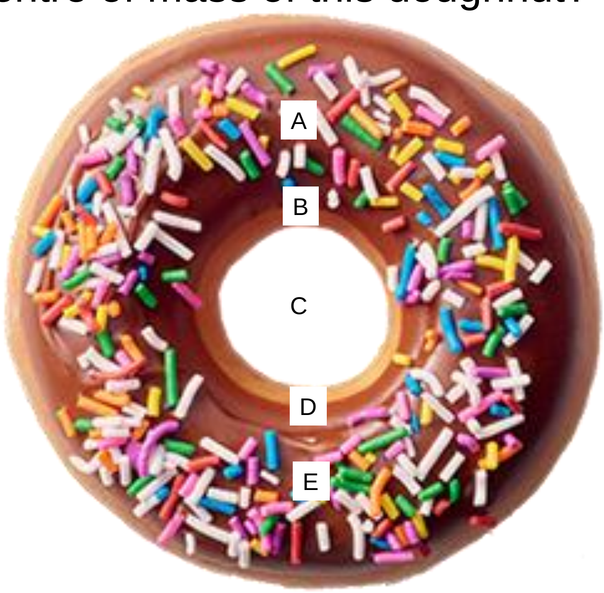
Poll Question

- Where is the centre of mass of this doughnut?



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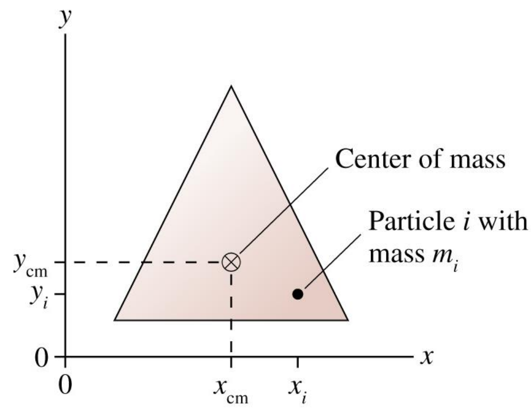
Centre of Mass

Consider an object made of particles. Particle *i* has mass m_i. The center-of-mass is at

$$x_{cm} = \frac{1}{M}\sum_i m_i x_i = \frac{m_1 x_1 + m_2 x_2 + m_3 x_3 + \cdots}{m_1 + m_2 + m_3 + \cdots}$$

$$y_{cm} = \frac{1}{M}\sum_i m_i y_i = \frac{m_1 y_1 + m_2 y_2 + m_3 y_3 + \cdots}{m_1 + m_2 + m_3 + \cdots}$$

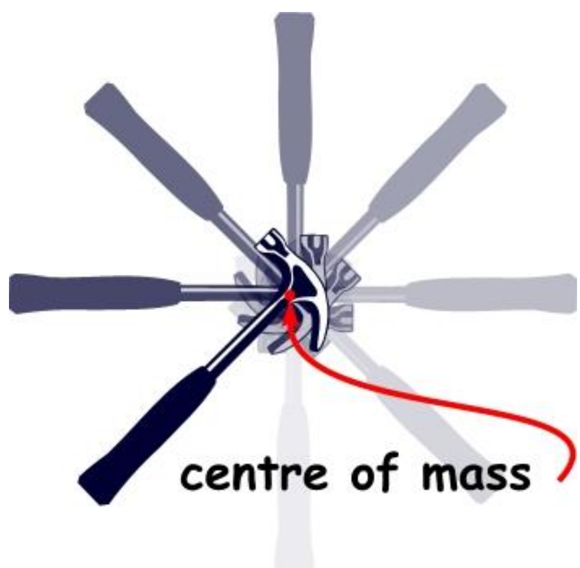


Calculating center of mass is much like calculating your grade-point average. Marks in full-courses count twice as much as marks in half-courses. Particles of *higher mass* count *more* than particles of lower mass.

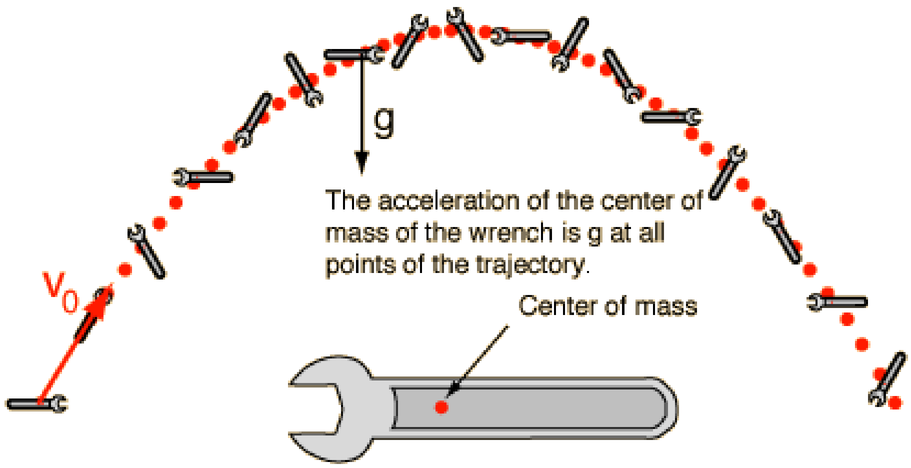
Rotation About the Center of Mass

An unconstrained object (i.e., one not on an axle or a pivot) on which there is no net force rotates about a point called the center of mass.

The center of mass remains motionless while every other point in the object undergoes circular motion around it.



[Image from http://resources.yesican-science.ca/discover_2006_2/images/hammer2.jpg]



[image from http://hyperphysics.phy-astr.gsu.edu/hbase/mechanics/n2ext.html]

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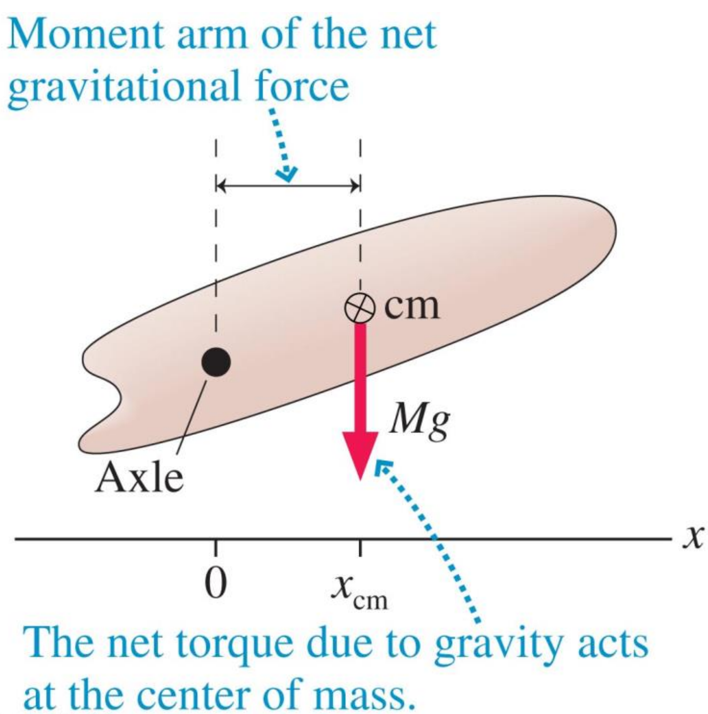
Gravitational Torque

- When calculating the torque due to gravity, you may treat the object as if all its mass were concentrated at the centre of mass.



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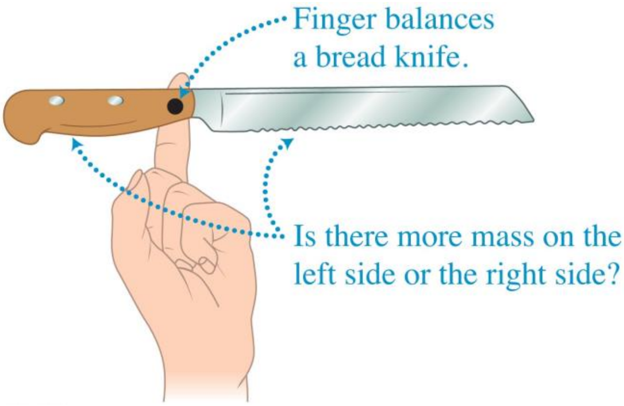
Mass distribution and center of mass

- When an object with distributed mass is in static equilibrium, the torques produced by gravity on the objects on each side of the center of mass have equal magnitudes.



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TeamUp Time!!

- Today you will be doing three multiple choice questions, all from Chapter 8, as a team of 2-4 students in your Practicals Pod.
- Your pod-team shares the mark!
- I'm going to mute here for 10 minutes; right now you should open Microsoft Teams and someone (most recent Facilitator) should place a **video call** to all 3 or 4 members of your Pod-Chat.

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Now: TeamUp! You have 10 minutes

- The first step is to decide who will be the TeamUp **Driver**
- All students must log-in to Quercus [You will now have three windows open: my zoom lecture, Microsoft Teams, and Quercus]
- **Non-drivers**: Wait!
- **Driver**: Go to the TeamUp Quiz Ch.8 in Module 4, click Go to Tool, then Create a Group. Let everyone in the Breakout Room know the session ID. Then WAIT – don't drive off alone!
- **Non-drivers**: Once you get the session ID, go to the TeamUp Quiz in this module, click Go to Tool, then Join Session and type the ID you were given.
- Once everyone in your room arrives in TeamUp, start going through the questions. Please **achieve consensus** before the driver submits.
- YOU MAY BEGIN! I'm going to go on mute for 10 minutes. Note: if your pod-mates are available on Microsoft Teams right now, go to the PHY131 Help Centre and I'll set up breakout rooms there. Zoom Meeting ID: 938 0964 2256, Passcode: 723874

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Question 1 Discussion

Two objects, of masses *m* and 2*m*, are hanging from opposite ends of a uniform horizontal beam. The beam is being supported by a string at its center, and the objects are balanced. Which of the following must be true?

A) The objects are hanging at the same distance from the center of the beam.
B) The object of mass 2*m* is twice the distance from the center of the beam.
C) The object of mass *m* is twice the distance from the center of the beam.
D) The mass of the beam must be known.

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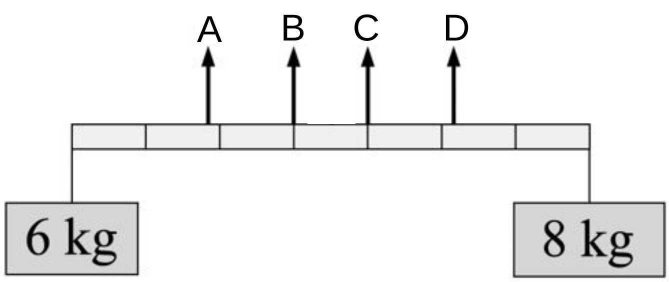
Question 2 Discussion

Two objects, of masses 6 and 8 kg, are hung from the ends of a stick that is 70 cm long and has marks every l0 cm, as shown above. If the mass of the stick is negligible, at which of the points indicated should a cord be attached if the stick is to remain horizontal when suspended from the cord?



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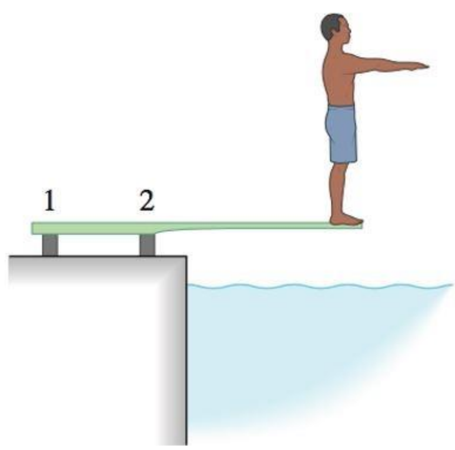
Question 3 Discussion



A man is standing on a diving board. The board is fixed in place at two points, 1 and 2. The board has negligible mass.

Which of the following is true about F1 and F2, the forces exerted by the piers at points 1 and 2 on the board?

A) F1 is pushing upward, and F2 is pulling downward.

B) Both F1 and F2 are pushing upward.

C) F1 is pulling downward, and F2 is pushing upward.

D) F1 or F2 may be more than one combination of pushing upward or pulling downward, depending on the mass of the man and the length of the board.

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Static Equilibrium Problems

• In equilibrium, an object has no net force and no net torque.

• Draw an extended free-body diagram that shows where each force acts on the object.

• Set up x and y axes, and choose a rotation axis. All of these choices should be done to simplify your calculations.

• Each force has an x and y component and a torque. Sum all of these up.

• Three equations which you can use are:

$$\sum F_x = 0 \qquad \sum F_y = 0 \qquad \sum \tau = 0$$

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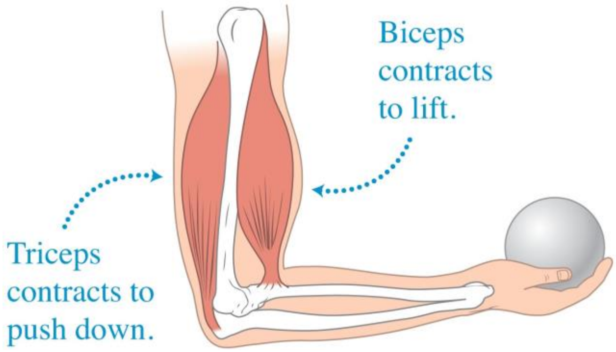
8.3 Skills for analyzing situations using equilibrium conditions



- When you hold a ball in your hand, your bicep muscle tenses and pulls up on your forearm in front of the elbow joint.
- When you push down with your hand on a desk, your triceps muscle tenses and pulls up on a protrusion of the forearm behind the elbow joint.
- The equations of equilibrium allow you to estimate these muscle tension forces

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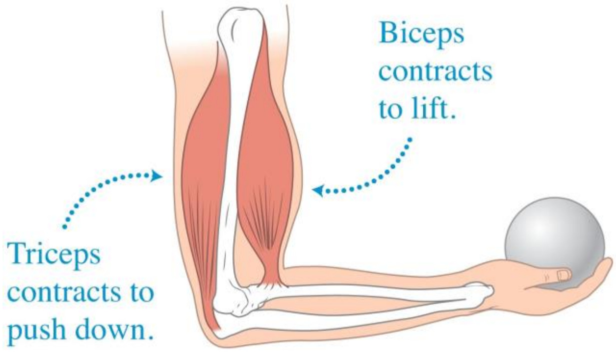
8.3 Skills for analyzing situations using equilibrium conditions



- **Example Problem:**
- You hold a 6.0 kg lead ball in your hand with your arm bent, as shown. The ball is 35 cm from the elbow joint. The biceps attach to the forearm 5.0 cm from the elbow joint. The forearm has a mass of 1.2 kg, and its centre of mass is 16 cm from the elbow joint. What is (a) the force of the biceps on the forearm, and (b) the force of the upper arm on the elbow joint?

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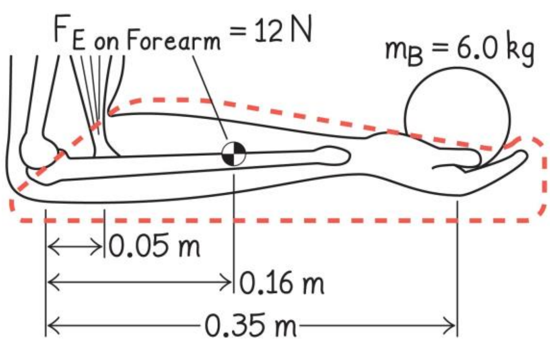
8.3 Problem-solving strategy: Applying static equilibrium conditions

SKETCH & TRANSLATE.

- Construct a labeled sketch of the situation. Include coordinate axes and choose an axis of rotation.
- Choose a system for analysis.



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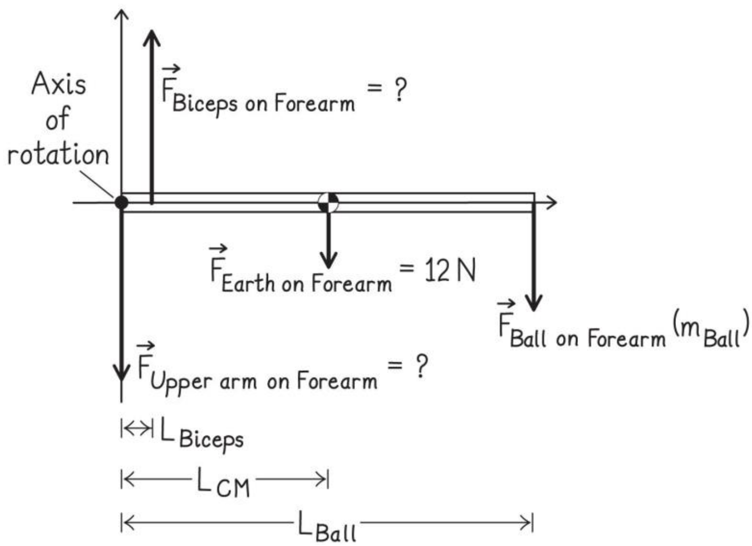
8.3 Problem-solving strategy: Applying static equilibrium conditions

SIMPLIFY & DIAGRAM

- Decide whether you will model the system as a rigid body or as a point-like object.
- Construct a force diagram for the system. Include the chosen coordinate system and the axis of rotation (the origin of the coordinate system).



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8.3 Problem-solving strategy: Applying static equilibrium conditions

REPRESENT MATHEMATICALLY

- Use the force diagram to apply the conditions of equilibrium.

SOLVE & EVALUATE

- Solve the equations for the quantities of interest.
- Evaluate the results. Check whether their magnitudes are reasonable and whether they have the correct signs and units. Also see if they have the expected values in limiting cases.

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Example

What is (a) the force of the biceps on the forearm, and (b) the force of the upper arm on the elbow joint?

SIMPLIFY & DIAGRAM

REPRESENT MATHEMATICALLY

SOLVE & EVALUATE

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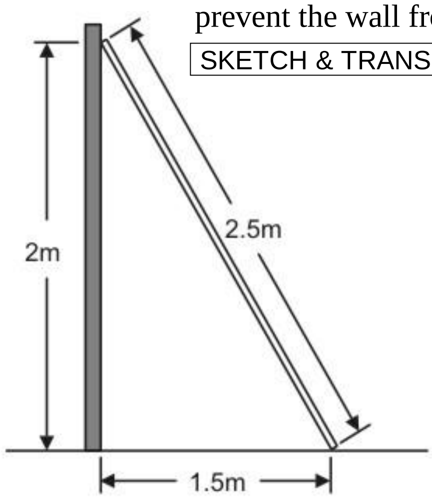
Example

A uniform ladder leans against a wall, as shown. The wall is frictionless. What is the minimum coefficient of static friction between the ladder and floor needed to prevent the wall from slipping?

SKETCH & TRANSLATE.



SIMPLIFY & DIAGRAM

REPRESENT MATHEMATICALLY

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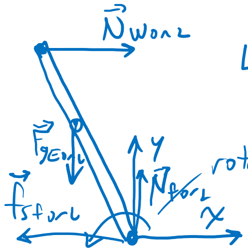
SIMPLIFY & DIAGRAM



L = length of ladder = 2.5 m

rotation axis, counter-clockwise = +

REPRESENT MATHEMATICALLY

Equilibrium: $\Sigma F_x = 0$, $\Sigma F_y = 0$, $\Sigma \tau = 0$.

$$\Sigma F_x = N_{WonL} - f_s = 0$$

$$\Sigma F_y = N_{FonL} - mg = 0$$

$$\Sigma \tau = -N_{WonL}(2m) + mg(0.75m) = 0$$

$f_s = f_{s\,max} = \mu_s N_{FonL}$ "just about to slip."

SOLVE & EVALUATE

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Have an amazing Reading Week!

- Get outside!! It's going to be warm this weekend and early next week!
- Get some exercise and fresh air.
- Get some sleep.
- Please do finish reading Chapter 8 before we come back on Monday Nov. 16.

- The Synchronous Midterm Assessment 4 on Tuesday Nov. 17 will be two problems you must solve using the 4-step method.
- One will be from Chapter 7, the other will be from Chapter 8. You'll be using crowdmark to upload an image or PDF of your work.

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