PHY131H1F - Class 25

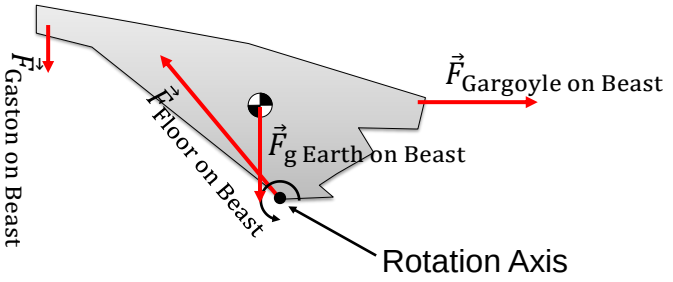
Define Beast = “system”

- Welcome back from break!
- What was I doing on my break?
- I did get outdoors a lot… I did also check out a few things on Disney+ with my kids!

Today:

8.5 Static Equilibrium Problems

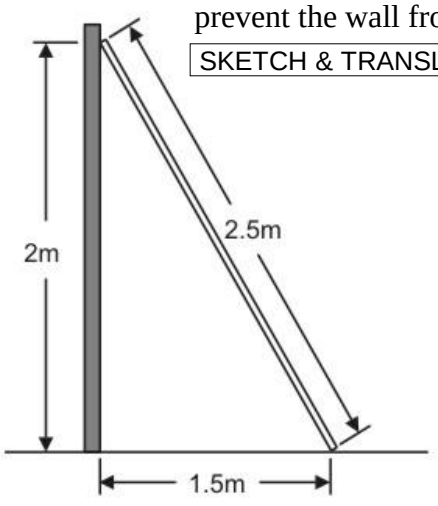
8.6 Stability



1

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

2

SIMPLIFY & DIAGRAM

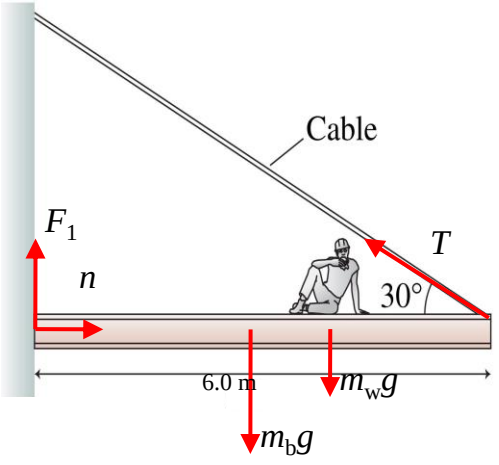
REPRESENT MATHEMATICALLY

SOLVE & EVALUATE

3

You Try!! Poll Question

- A construction worker of mass m_w sits 2.0 m from the end of a steel beam of mass m_b, as shown.
- The tension in the Cable is T
- The wall exerts a normal force, n on the beam, and an upward force, F_1.
- Define $+x$ = to the right, $+y$ = up, and the pivot is the point where the beam touches the wall.
- What is the normal force, n?



A. $(m_b + m_w)g$
B. $(m_b + m_w)g - T\cos(30°)$
C. $(m_b + m_w)g - T\sin(30°)$
D. $T\sin(30°)$
E. $T\cos(30°)$

4

You Try!! Poll Question

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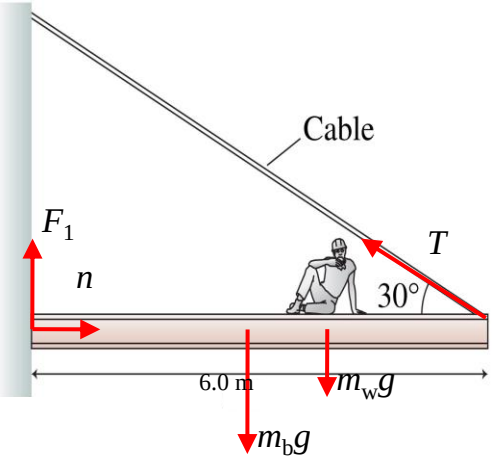

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5

A uniform steel beam of length L and mass m_1 is attached via a hinge to the side of a building. The beam is supported by a steel cable attached to the end of the beam at an angle θ, as shown. Through the hinge, the wall exerts an unknown force, $\vec{F}$, on the beam. A workman of mass m_2 sits eating lunch a distance d from the building.

a) Find T, the tension in the cable.

b) Find F_x, the x-component of the force exerted by the wall on the beam ($\vec{F}$), using the axis shown.

SKETCH & TRANSLATE.

SIMPLIFY & DIAGRAM

REPRESENT MATHEMATICALLY

6

SIMPLIFY & DIAGRAM

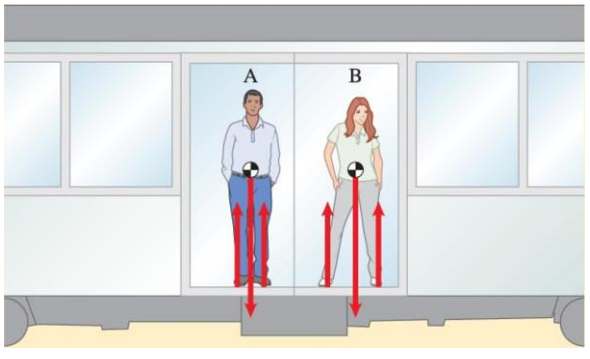
REPRESENT MATHEMATICALLY

SOLVE & EVALUATE

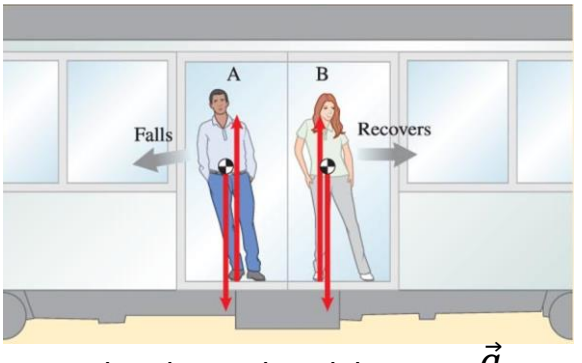
7

Equilibrium and tipping objects

- You have probably observed that it is easier to balance and avoid falling while standing in a moving bus or subway train if you spread your feet apart in the direction of motion.
- By assuming this stance, you increase the **area of support**—the area of contact between an object and the surface it is supported by.



Train At Rest



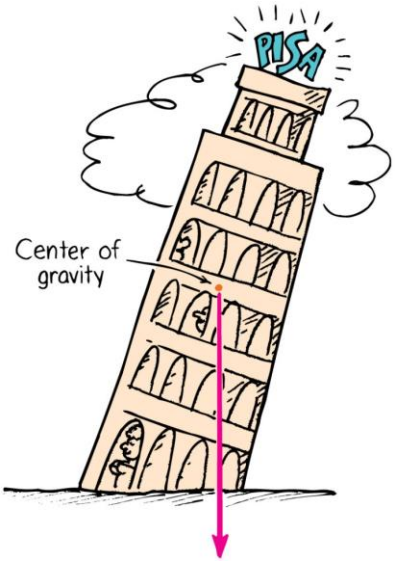
Accelerating to the Right $\vec{a}$

8

Centre of Gravity—Stability

The location of the centre of gravity is important for stability.

- If we draw a line straight down from the centre of gravity and it falls inside the base of the object, it is in stable **equilibrium;** it will balance.
- If it falls outside the base, it is unstable.



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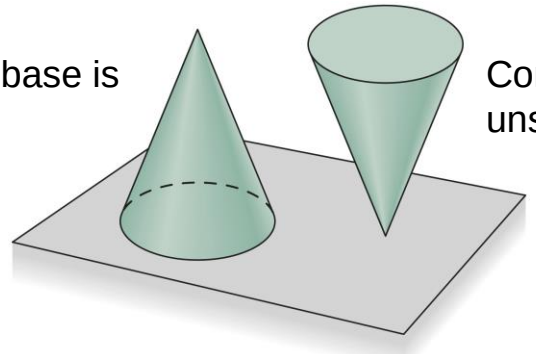
Stability

- An equilibrium is stable if a slight disturbance from equilibrium results in forces and/or torques that tend to restore the equilibrium.

- An equilibrium is unstable if a slight disturbance causes the system to move away from the original equilibrium.

Cone on its base is stable



Cone on its tip is unstable

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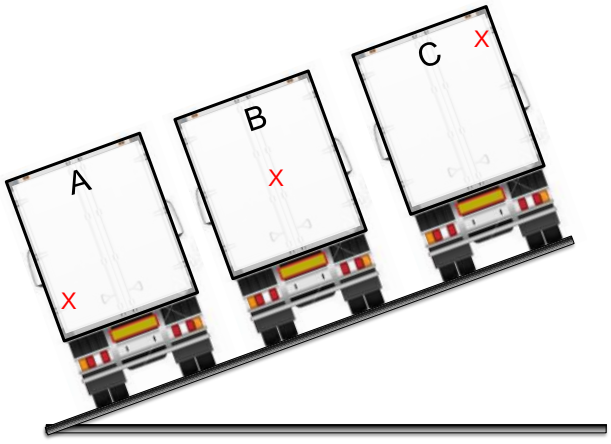
Poll Question

The centres of gravity of the three trucks parked on a hill are shown by the Xs. Which truck(s) will tip over?



D. All three of the trucks will tip over.
E. None of the three will tip over.

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A refrigerator is 2.0 m high, and 1.4 m wide. On a flat floor, by what maximum angle can it tip sideways and still not fall over on its side?

SKETCH & TRANSLATE.

SIMPLIFY & DIAGRAM

REPRESENT MATHEMATICALLY

SOLVE & EVALUATE

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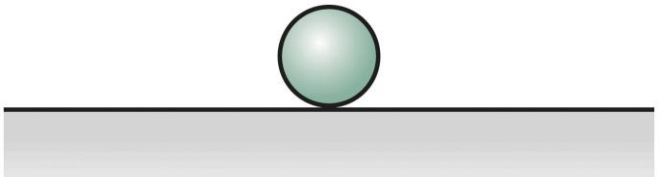
STABILITY JEOPARDY!

RIP Alex Trebek
1940-2020



It could look like this.

A. What is “Stable Equilibrium”?
B. What is “Neutrally Stable Equilibrium”?
C. What is “Unstable Equilibrium”?
D. What is “Metastable Equilibrium”?

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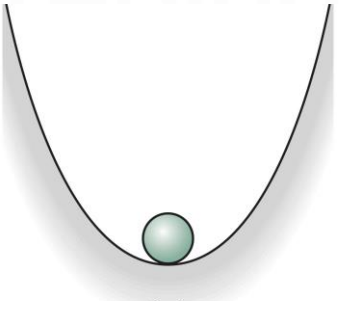
STABILITY JEOPARDY!



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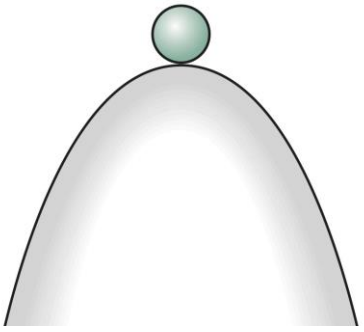

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15

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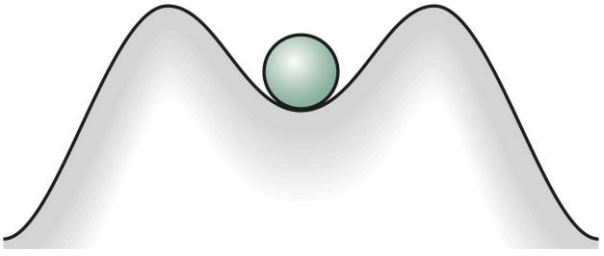

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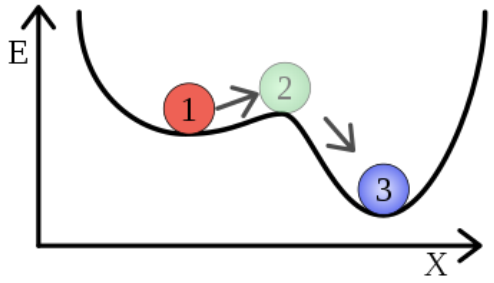
https://en.wikipedia.org/wiki/Metastability

Metastability



A metastable state of weaker bond (1), a transitional 'saddle' configuration (2) and a stable state of stronger bond (3).

- **Examples of Metastability:**
- A ball resting in a hollow on a slope. If the ball is only slightly pushed, it will settle back into its hollow, but a stronger push may start the ball rolling down the slope.
- Bowling pins. They may either merely wobble for a moment, or tip over completely.
- Isomerisation. Higher energy isomers are long lived as they are prevented from rearranging to their preferred ground state by small barriers in the potential energy.

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Midterm Assessment 4

- There will be two problems you must solve using the 4-step method.
- The solutions must be in your handwriting and written upon an Answer Template Sheet or something very similar.
- You will see both problems at once, starting tomorrow at 8:10pm Toronto time. One will be from Chapter 7, and the other from Chapter 8.
- You will get an email from crowdmark, and also there will be a link on the Quercus under Module 4.
- You have 30 minutes to write out your solutions to both.
- There is an additional 5 minutes which you should allow for uploading the file.
- All uploads must be complete by 8:45pm, 30 minutes after the start time.
- Your images should ideally be PDFs or JPEG images.
- Worst-case scenario if crowdmark fails is you can attach your images in an email to phy131fall@physics.utoronto.ca . (But please only do this if crowdmark fails.)

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Before Class 26 on Wednesday

- Don’t forget to do the quiz on Tuesday evening!
- Also, please read:
- 9.1 Rotational Kinematics
- 9.2 Rotational Inertia

Have you ever wondered: How do figure skaters spin so quickly?

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