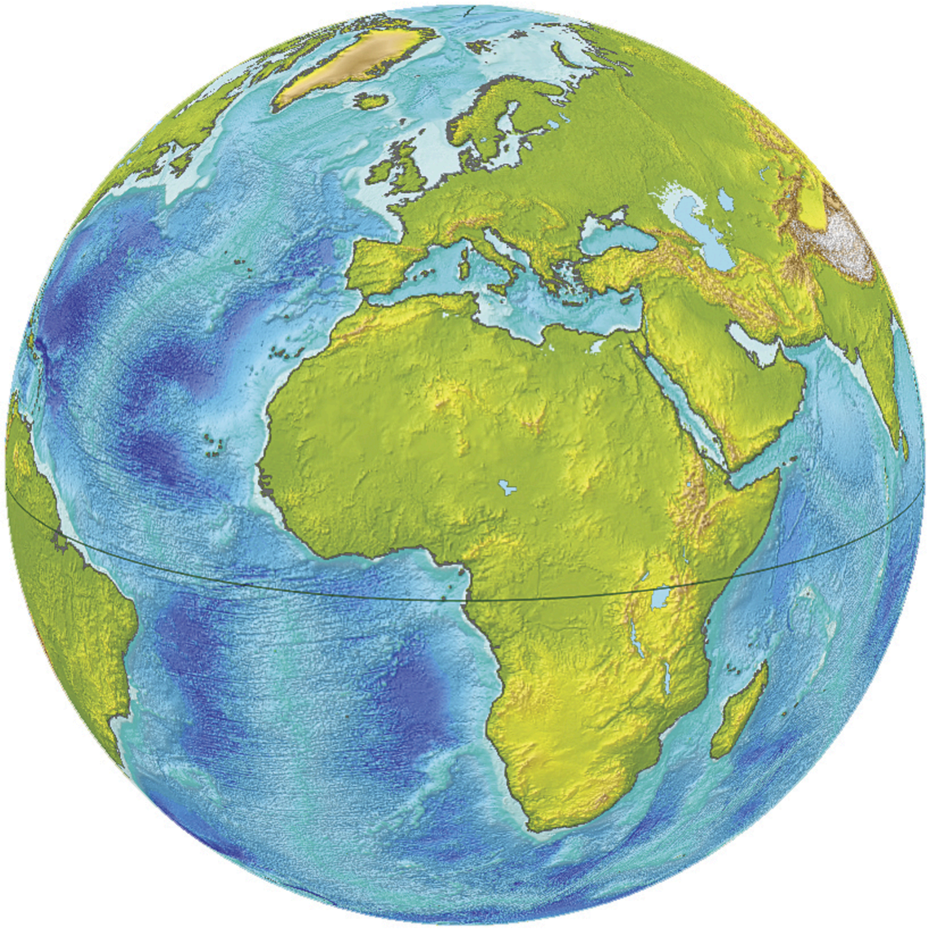
Chapter 4.
Turning Effect

New Words

moment, equilibrium, clockwise, anti-clockwise, pivot/fulcrum, axle, hinge, beam, laminae, suspend, tilt, see-saw, spanner, bolt, wheelbarrow

Turning Effect

Turning Effect



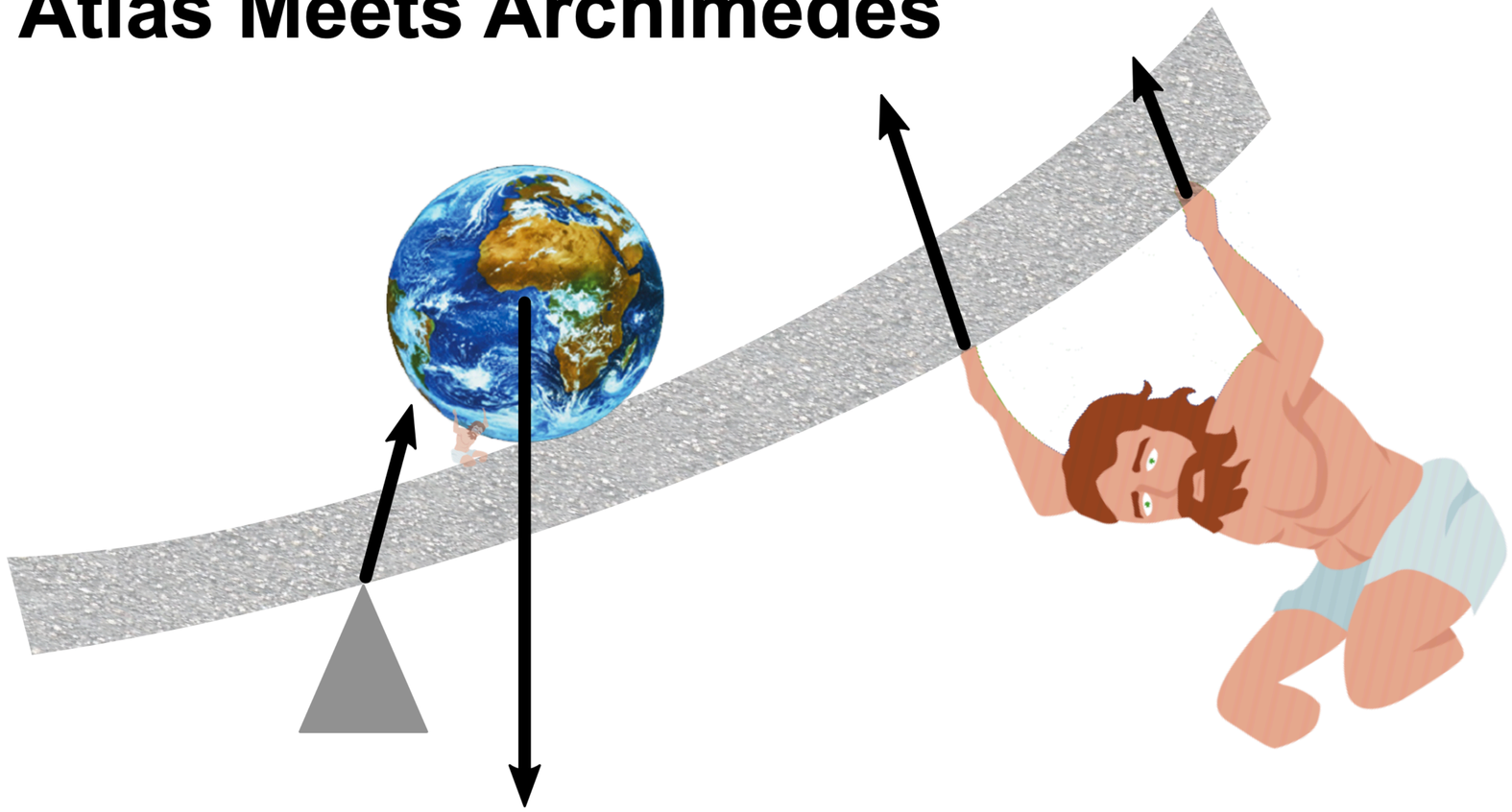
"δῶς μοι πᾶ στῶ καὶ τὰν γᾶν κινάσω."
Give me the place to stand, and I shall move the earth.

Archimedes of Syracuse

https://www.esri.com/news/arcuser/0610/graphics/nospin_1-lg.jpg

Turning Effect

Atlas Meets Archimedes



Turning Effect

turning effect: when a force causes an object to rotate or would make an object to rotate if there were no resistive force

Where does the turning effect come from?

pivot: the point which the object can rotate about.

★**The moment of force =** Force × ***perpendicular*** distance to the pivot

moment arm

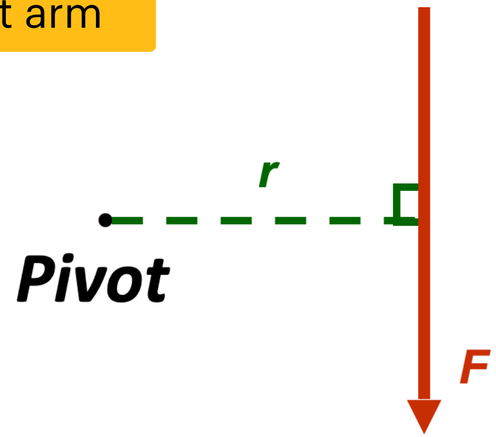
Equation: $M = F \times r$

Unit: Nm

Moment is a **Vector** → direction → clockwise / anti-clockwise

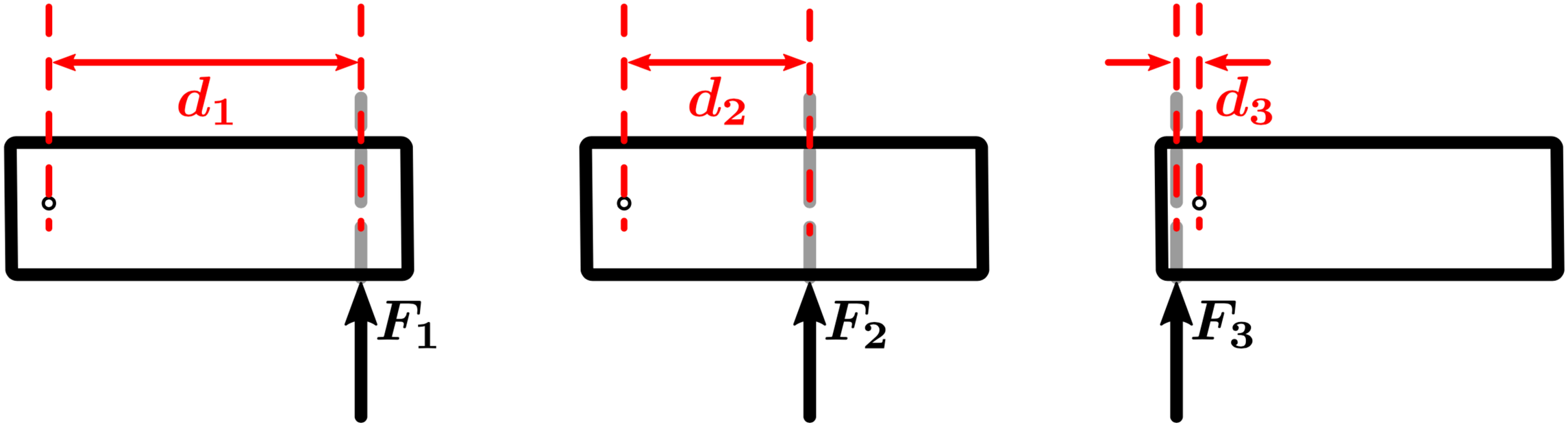
anticlockwise

clockwise

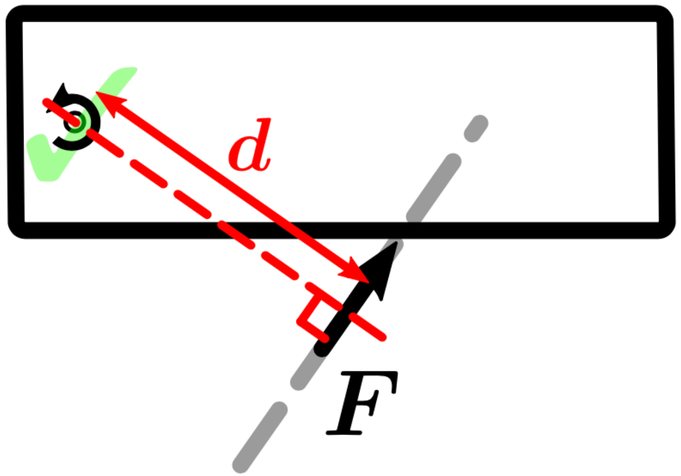


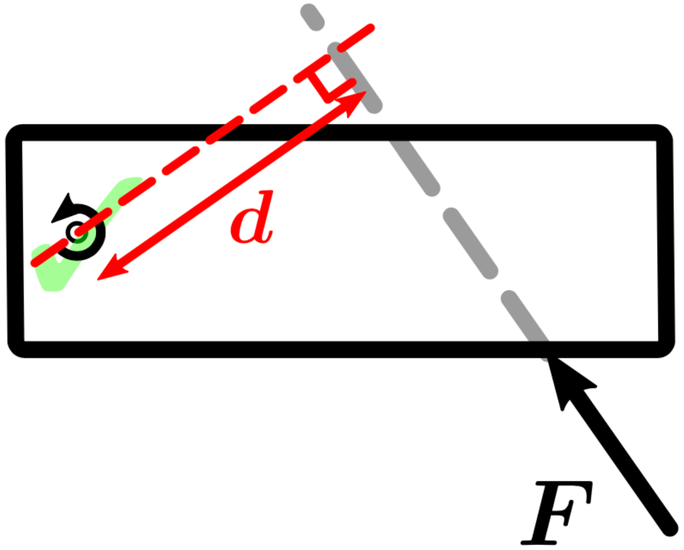
moment ≠ momentum

Moment Arm



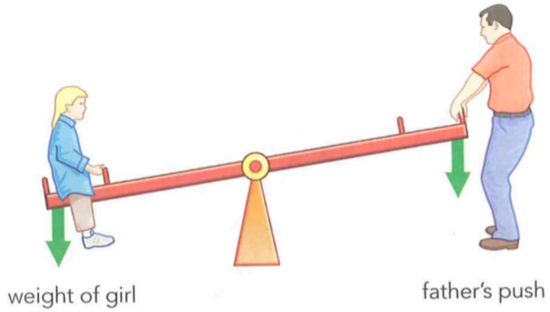
Moment Arm





Exercise

What are the perpendicular distance from the pivot? What are the direction of the moments?

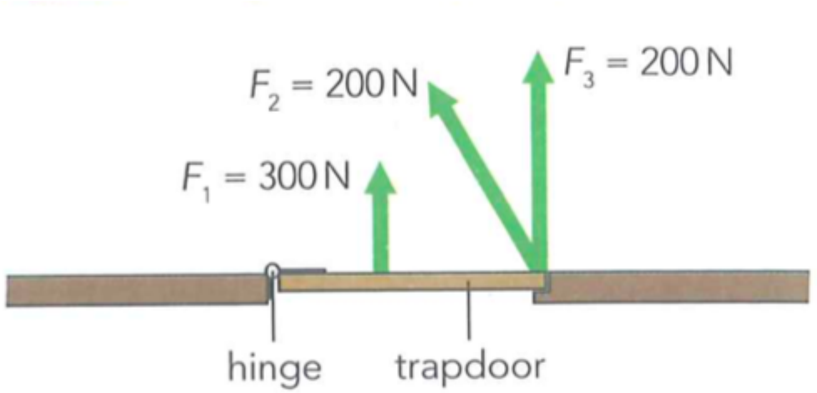


How to make the **larger** turning effect?

- Larger force
- Act further from pivot
- Act perpendicular to the object

Exercise

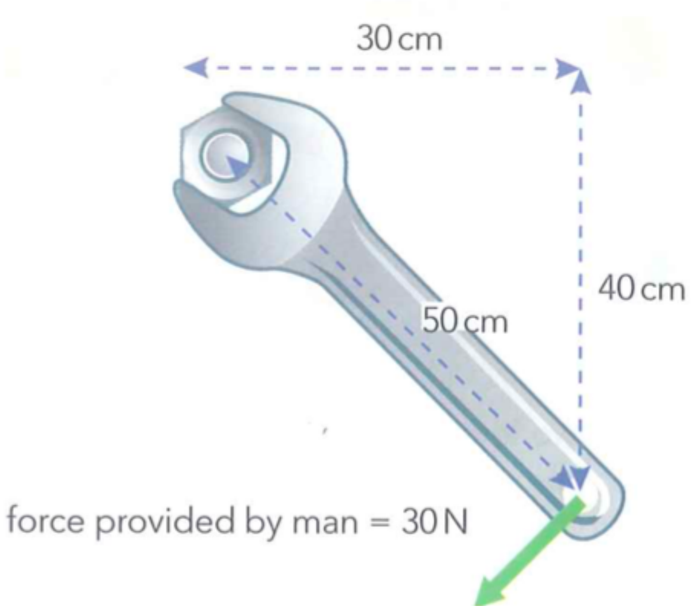
Which of the following force have the **largest** turning effect?



Exercise

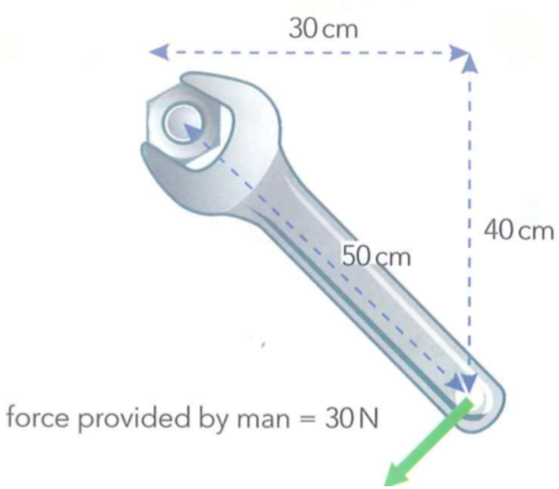
Explain why somebody would use a spanner with a longer handle if they needed to undo a tight bolt?

Large spanner => longer distance to the pivot => large moment



Exercise

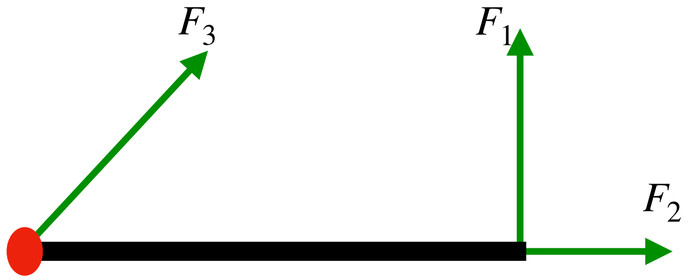
A bolt is tightened by applying a turning force of 30N to the end of the spanner.
Which of of three distance measurements should you use?
Use this distance to calculate the moment.



Exercise

Calculate moment of following forces?

$(F_1 = F_2 = F_3 = 2N,\ l = 1\,m)$



If (extended) line of force ***pass through the pivot***, then moment of this force to this pivot is **0** => not rotate

Exercise

Three simple machines are shown.

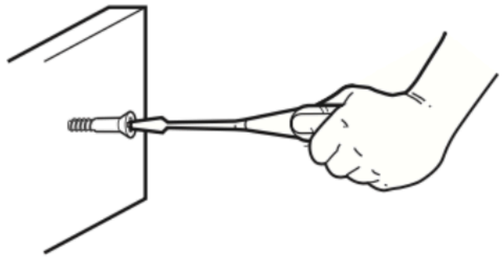
1

moving soil with
a wheelbarrow

2

cutting string
with scissors

3



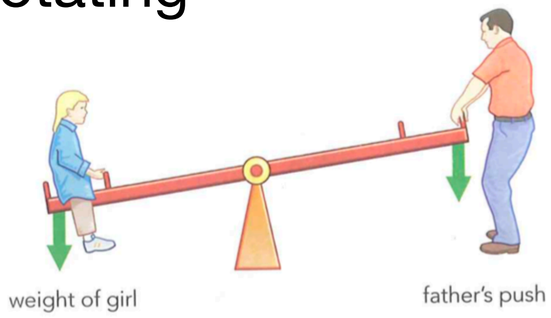
screwing a screw
with a screwdriver

Which machines are an application of the moment of a force?

A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

Equilibrium

Equilibrium: not moving, not rotating



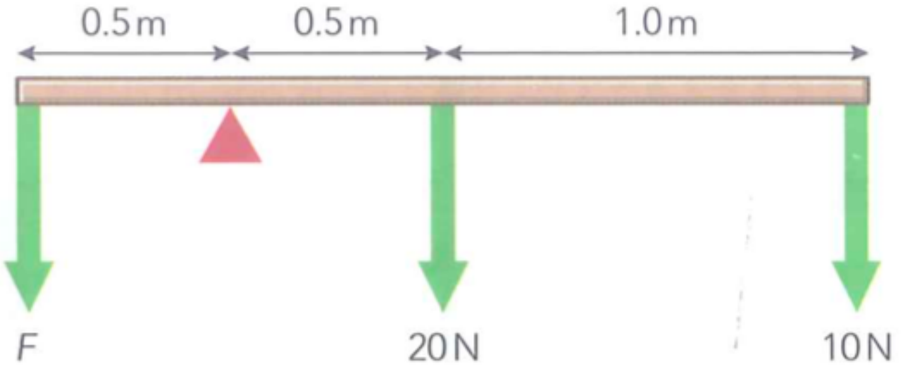
★Two conditions for Equilibrium:

- No resultant force
- No net moment (**clockwise moment = anti-clockwise moment**)

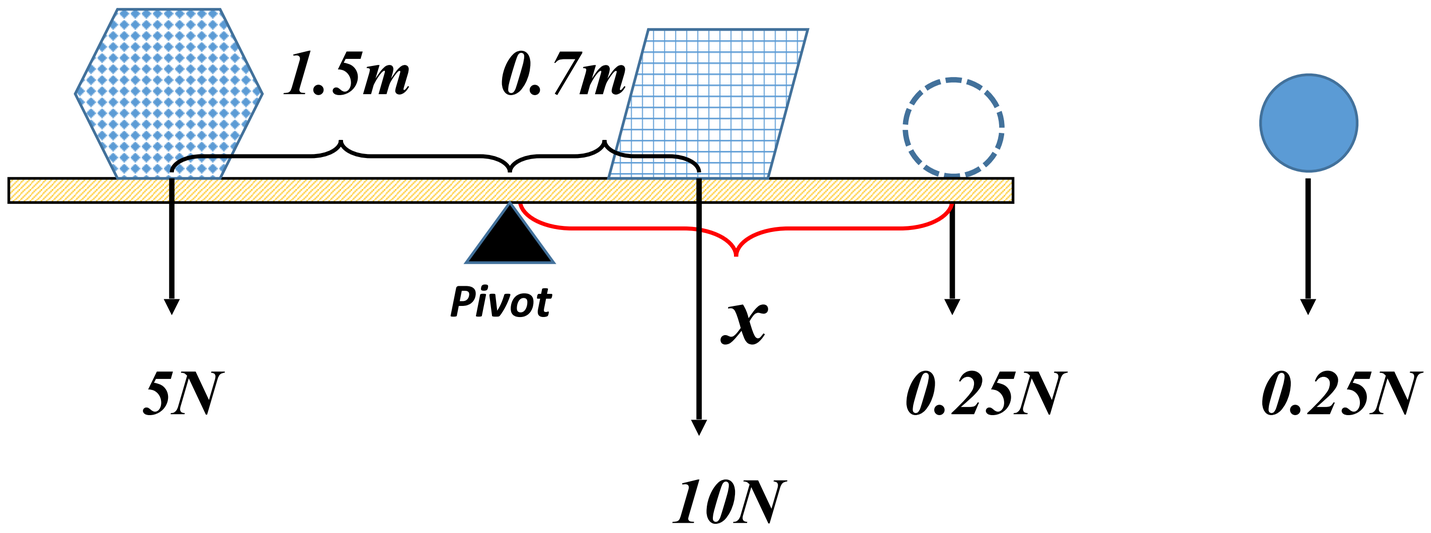
Principle of moment

Exercise

The beam is 2.0 meters long and has a weight of 20N(act at the center of the beam). It is pivoted as shown. A force of 10N acts downwards at one end. What force F must be applied downwards at the other end to balance the beam? Is the beam in equilibrium and why? If yes, is there any other force missing from the diagram below?



Where to place this ball to keep the lever balance?

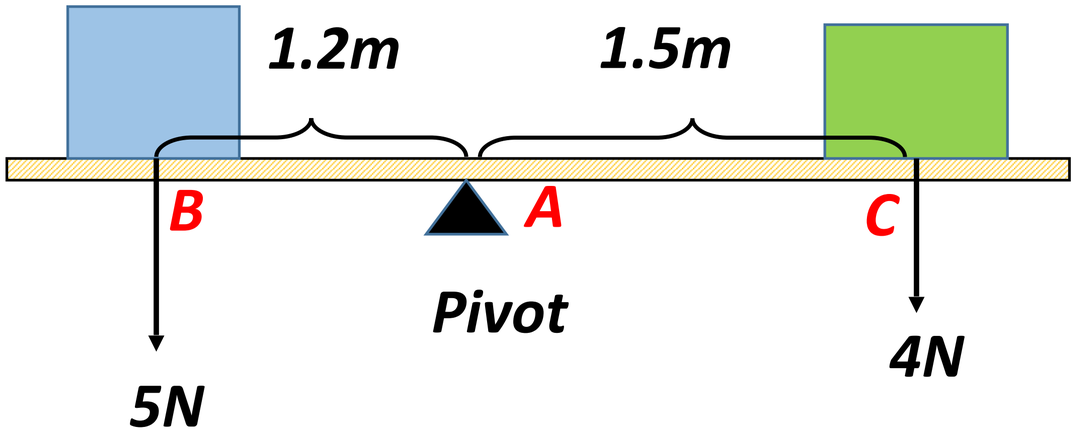


Anticlockwise moments **Clockwise moments**

$$5\ N \times 1.5\ m = 10\ N \times 0.7\ m + 0.25\ N \times x$$

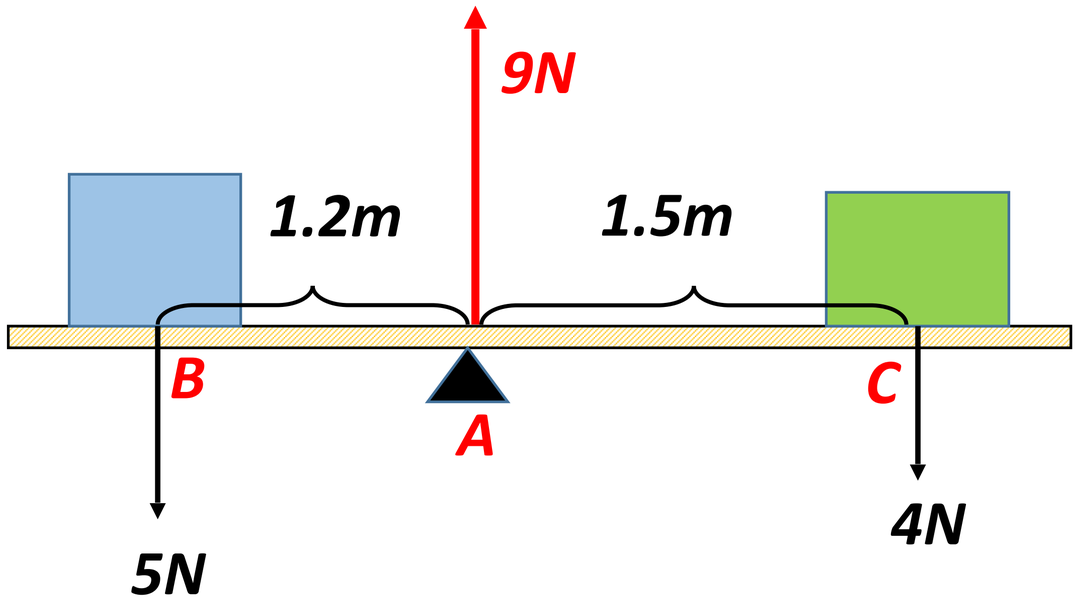
$$x = 2\ m$$

balance



When a system is balance, about any point, the sum of clockwise moments equals the sum of anticlockwise moments.

Taking moments about B



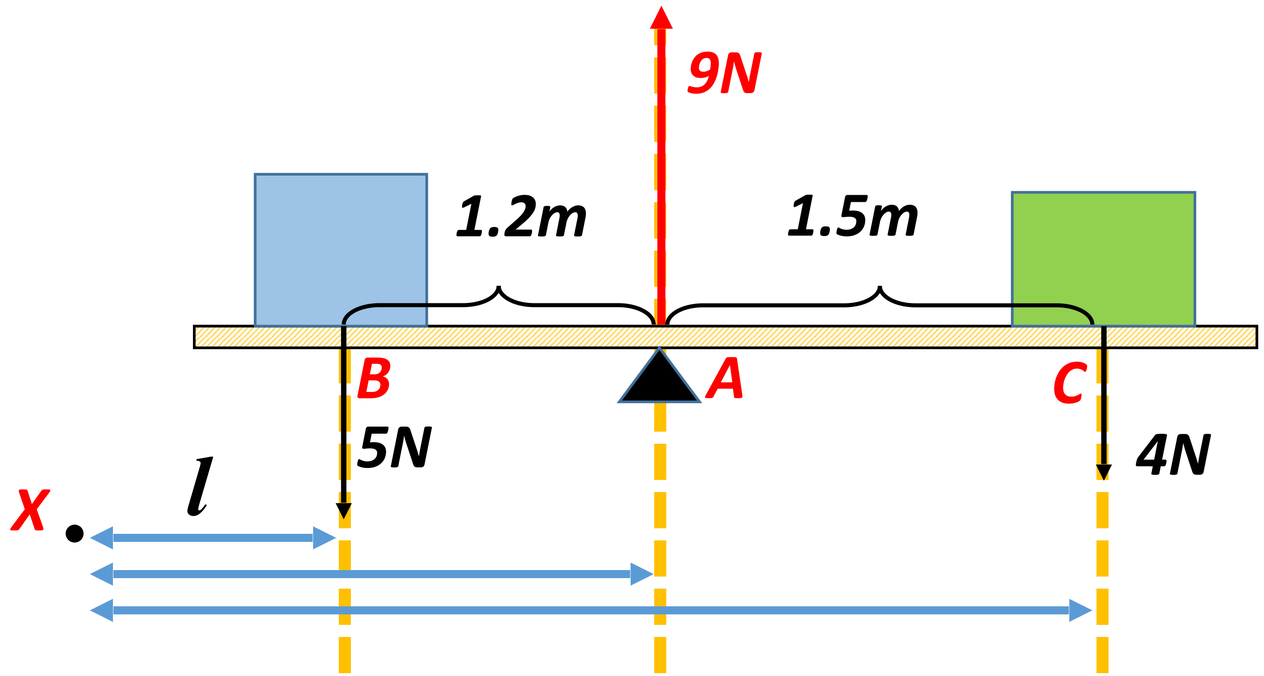
anticlockwise moments

$$9\ N \times 1.2\ m = 10.8\ Nm$$

clockwise moments

$$4\ N \times 2.7\ m = 10.8\ Nm$$

Taking moments about X



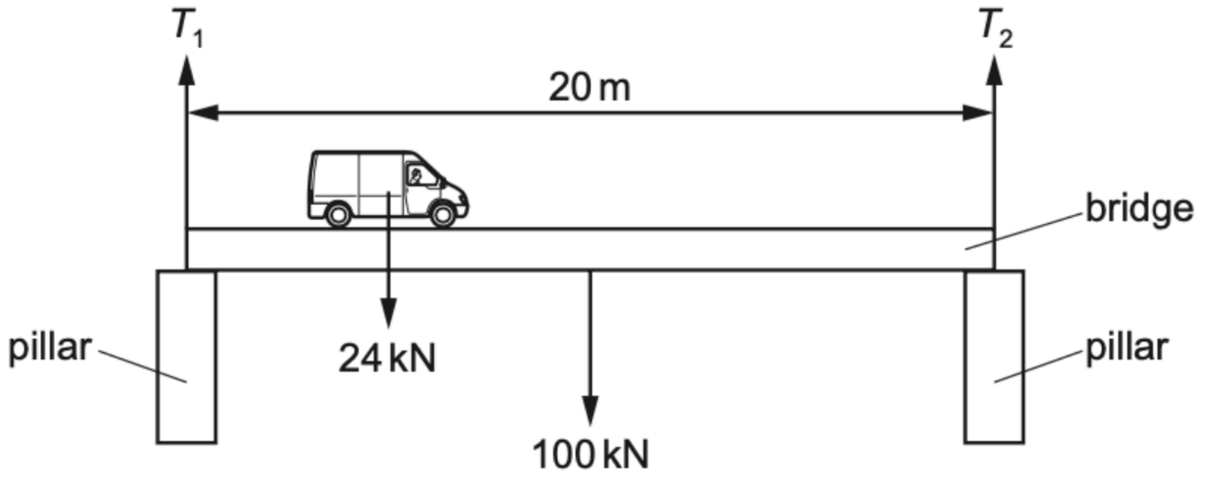
anticlockwise moments

$$9\times(l+1.2)=9\times l+10.8$$

clockwise moments

$$5\times l+4\times\ (l+2.7)=9\times l+10.8$$

A 20 m long, uniform bridge of weight 100 kN is supported at each end by pillars, as shown.



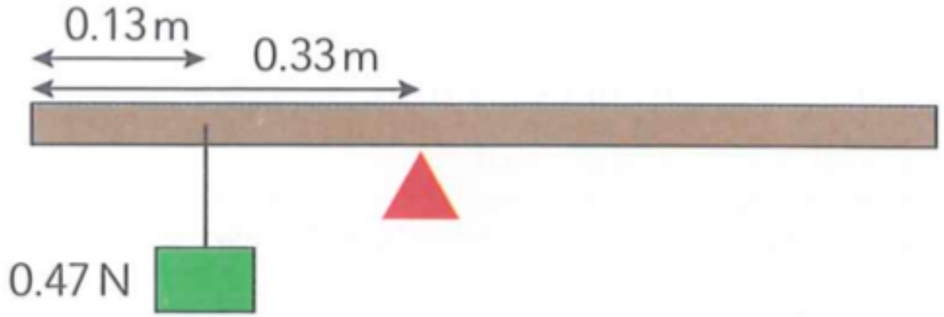
The pillars exert forces T_1 and T_2 on the ends of the bridge.

What are the values of T_1 and T_2 when a van of weight 24 kN is on the bridge, 5 m from the left-hand pillar?

	T_1 / kN	T_2 / kN
A	56	68
B	62	62
C	68	56
D	74	50

Exercise

A beam is balanced on a pivot 0.33 meters from its left-hand side.
The beam balances when a weight of 0.47N is suspended 0.13 meters from the same end.
i. calculate the anti-clockwise moment of the 0.47N force.
ii. what is the moment due to the weight of the rod?
iii. The weight of the rod is 0.79N. Calculate the position of its centre of gravity to the right of its pivot.



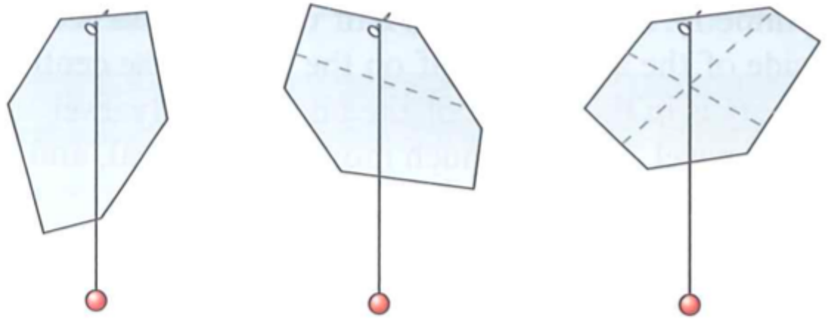
Exercise

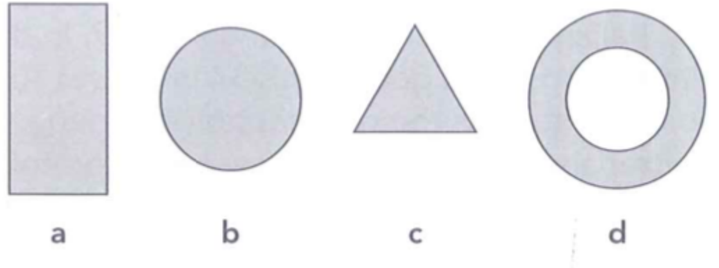
★**Center of gravity:** the point at which all of its gravity can be considered to act

How to get the center of gravity of an object?

a. For mass uniformly distributed object: at the geometric center

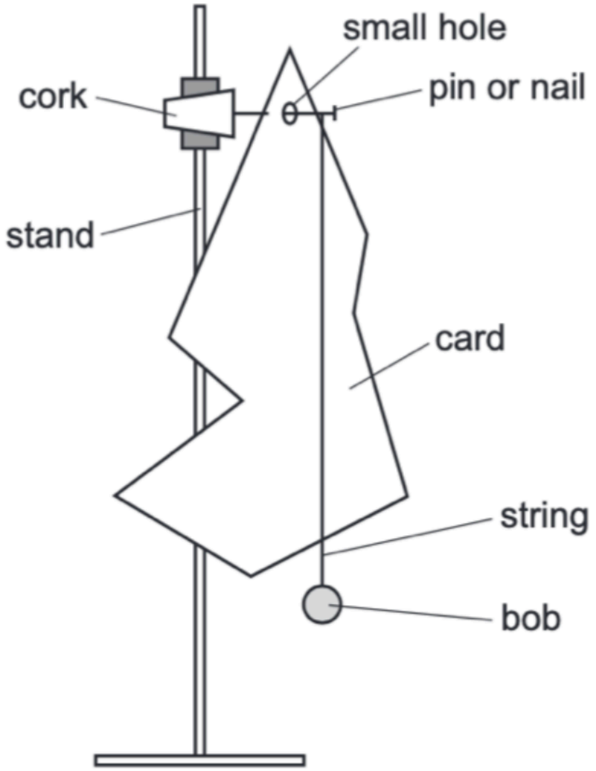
b. Otherwise: use Suspension (>2 times)





1.Hang up the card and suspend a plumb line from the same place.
2.**Mark the position of the thread**.
3.Repeat the above steps with the card suspended from different places.
4.Where these lines **intersect** is the centre of mass.

A student sets up the apparatus shown in the diagram to find the centre of mass of the card.



The student makes sure that the card, the string and the bob are all at rest.

What should the student do next?

A Mark a horizontal line on the card level with the middle of the string.

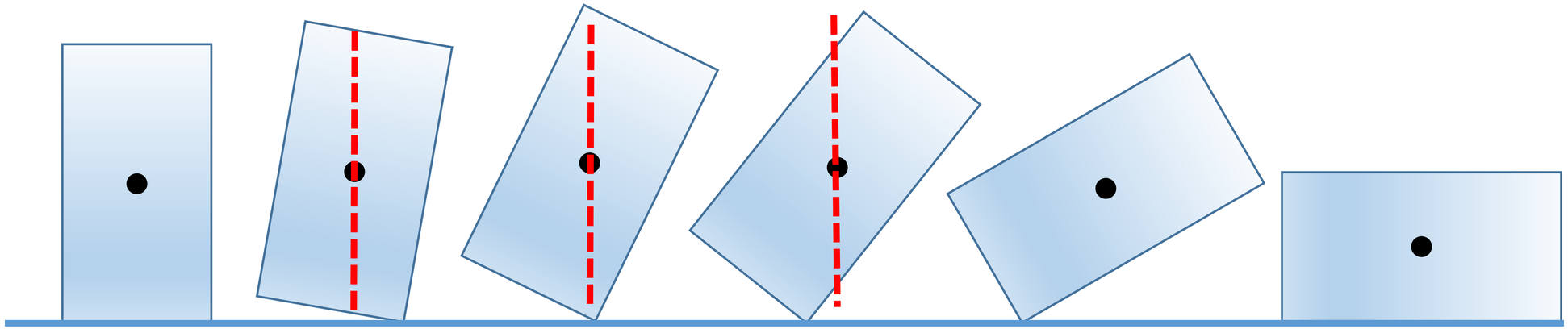
B Mark the line of the string on the card.

C Pull the bob on the string to one side and release it.

D Replace the bob with a heavier bob.

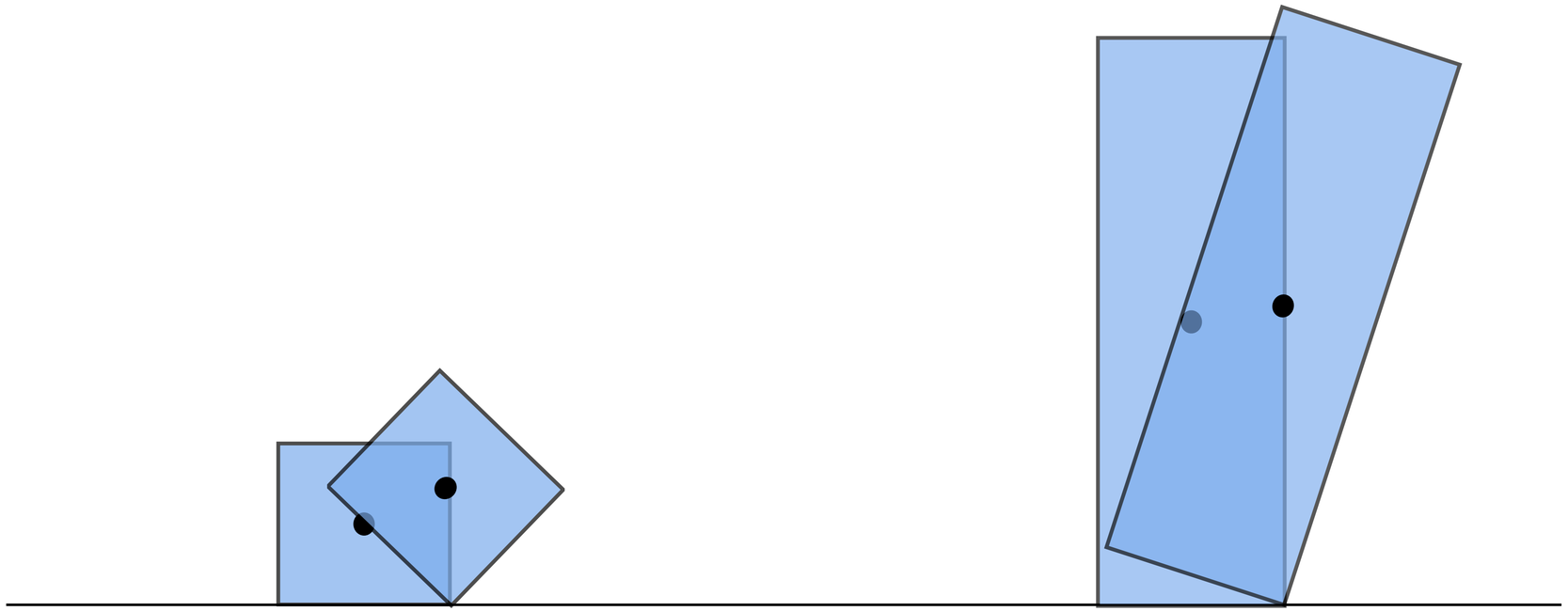
Stability

Why does an object topple?

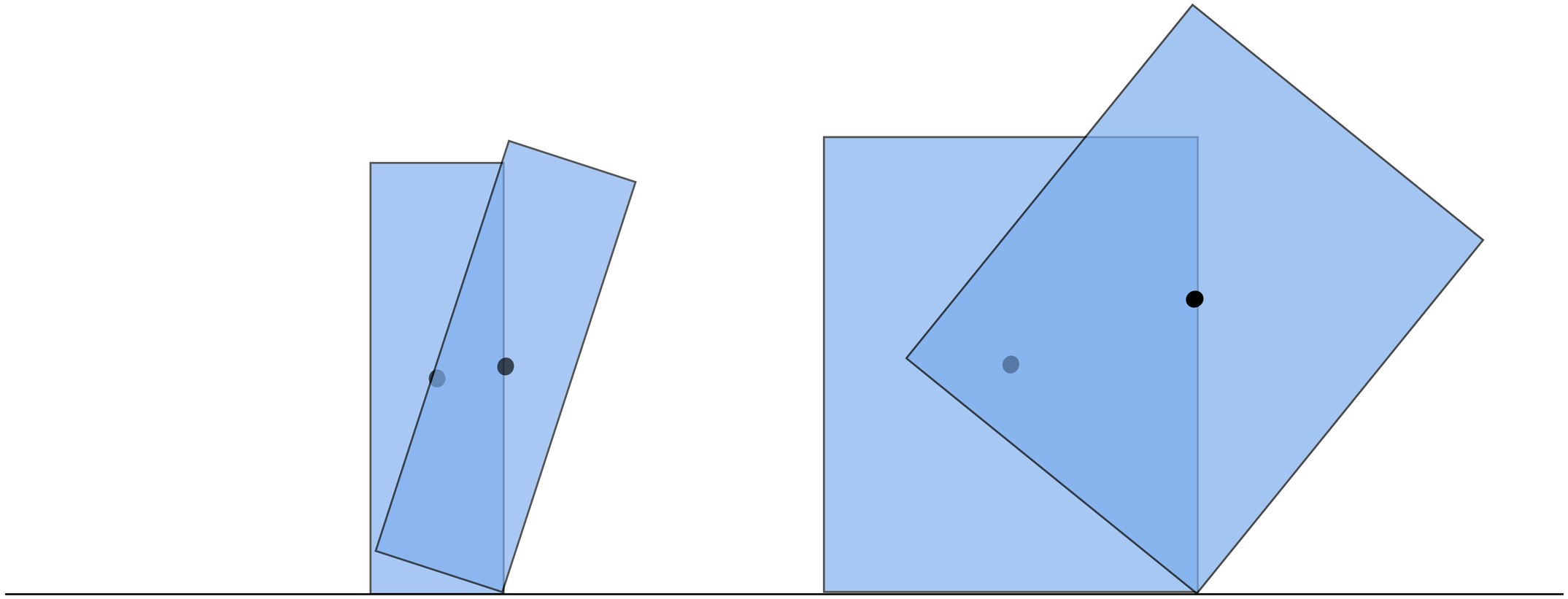


c.m. pass over the edge of its base

Stability



Stability



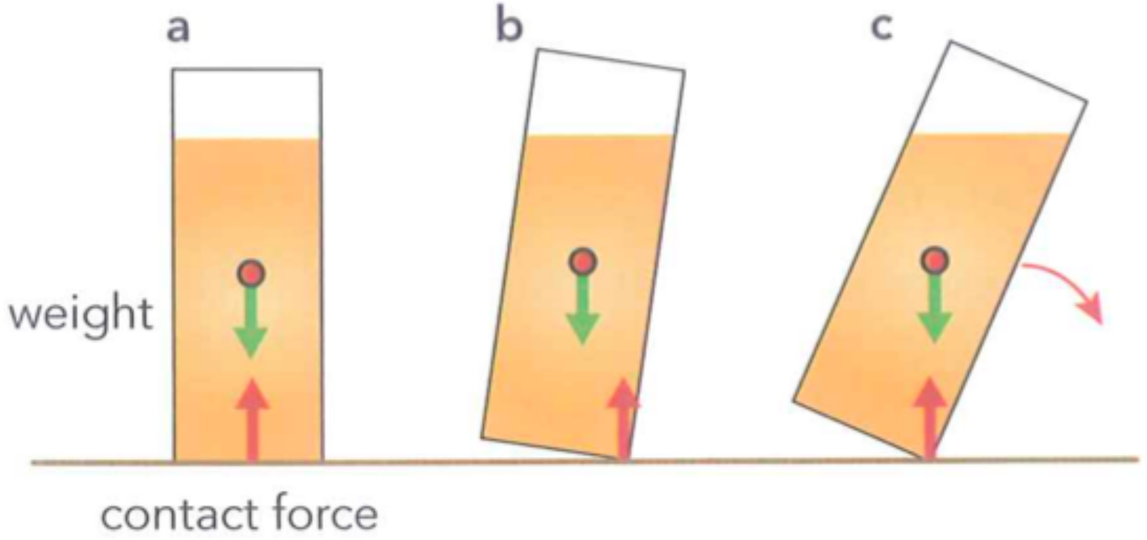
Stability

Which is more stable?

Lower center of gravity

Wider base

Stability

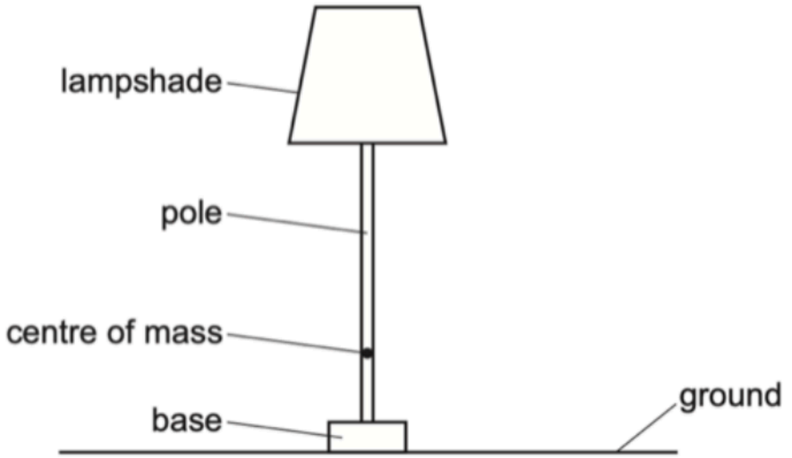


Stable: **low** center of gravity, **wide** base

Unstable: high center of gravity, narrow base

Exercise

23 The diagram shows a lamp.



Changing which feature increases the stability of the lamp?

A A larger lampshade

B A longer pole

C A heavier base

D A higher centre of mass

Exercise

Buses and other vehicles have to be tilt-tested to an angle of at least 28 degrees from the vertical before they can carry passengers.
Use the ideas of stability and center of gravity to explain why either bus in the figure would topple over if tilted any further. You can draw copies of the diagram to help with your explanation.

ii. Explain how the stability of the bus would be affected by having more passengers on the upper deck.

iii. Explain why bags of sand are only put on the top deck of bus B and not the lower deck.