Chapter 4 Turning effects of force

Contents:

New word list:

Suspend：悬挂 hang　　moment：力矩　　equilibrium：clockwise：anti-clockwise
Spanner: 扳手 undo:解开 hinge：合页（sticking point）
Pivot/fulcrum:支点
Wheelbarrow:独轮车
Axle: 轴
See-saw:跷跷板

1.5.2 Turning effect of forces

Core

1 Describe the moment of a force as a measure of its turning effect and give everyday examples
2 Define the moment of a force as moment = force × perpendicular distance from the pivot; recall and use this equation
3 Apply the principle of moments to situations with one force each side of the pivot, including balancing of a beam
4 State that, when there is no resultant force and no resultant moment, an object is in equilibrium

Supplement

5 Apply the principle of moments to other situations, including those with more than one force each side of the pivot
6 Describe an experiment to demonstrate that there is no resultant moment on an object in equilibrium

1.5.3 Centre of gravity

Core

1 State what is meant by centre of gravity
2 Describe an experiment to determine the position of the centre of gravity of an irregularly shaped plane lamina
3 Describe, qualitatively, the effect of the position of the centre of gravity on the stability of simple objects

Supplement

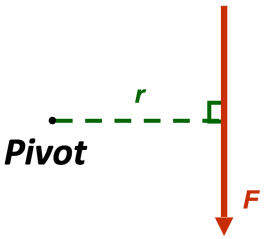
4.1 The moment of force

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

Archimedes of Syracuse

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? Moment of force

The moment of force = force * perpendicular distance to the pivot (moment arm)



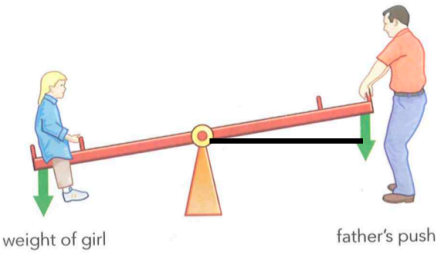
<u>Equation: M = r*F</u>

Unit: Nm

Vector → clockwise / anti-clockwise

Exercise 4.a

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

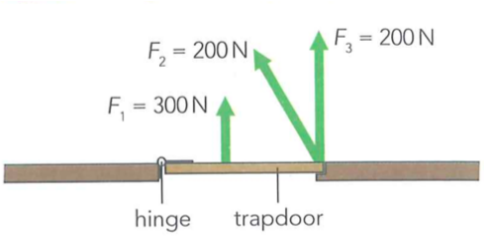


How to make the **largest** turning effect?

1. Larger force
2. Further from pivot
3. Acts on 90 degree to the object

Exercise 4.b:

Which of the following force have the largest turning effect?
F1*R1 < 2 F3* 1/2R3



Exercise 4.c

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

Bigger distance from the pivot so can apply a smaller force to achieve same turning effect.

Exercise 4.d

A bolt is tightened by applying a turning force of 30N to the end of the spanner.

A. Which of of three distance measurements should you use?
B. Use this distance to calculate the moment.

Exercise 4.e

Calculate moment of following forces?

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

$M_1 =$ $M_2 =$ $M_3 =$

When Line of action of force pass through pivot => Moment =0

4.2 Equilibrium

Def: two or more things are balanced/ no net force and no net moment

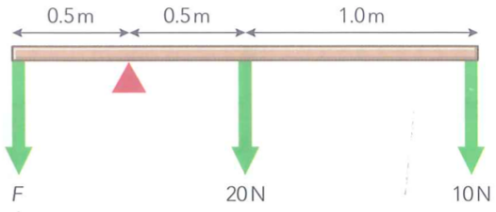
To be in equilibrium requires

- Resultant force =0
- Resultant moment =0 /clockwise moment = anti-clockwise moment

Principle of moment

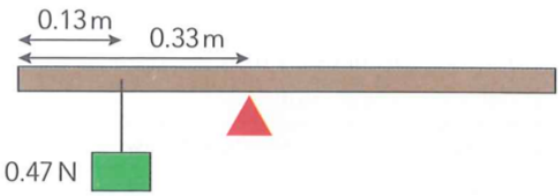
Exercise 4.f

The beam is 2.0 meters long and has a weight of 20N. 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?



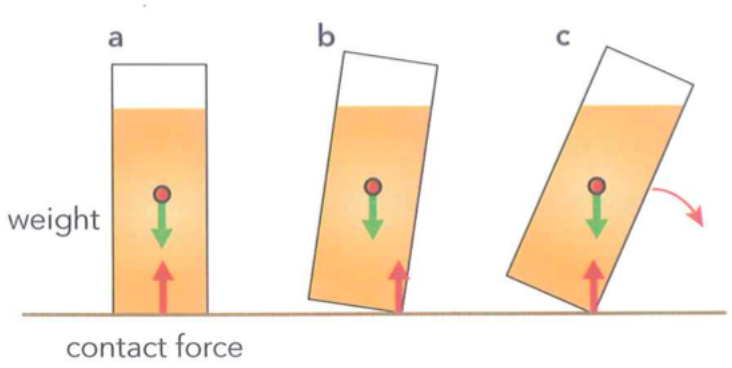
Exercise 4.g

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.



4.3 Stability and center of gravity

How can you tell if an object is stable or unstable? (Whether exceeds the base)

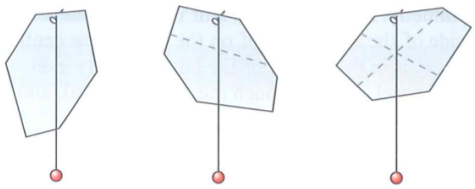


Center of gravity: all the mass of an object could be located here and the object would behave the same

How to get the center of gravity of an object?

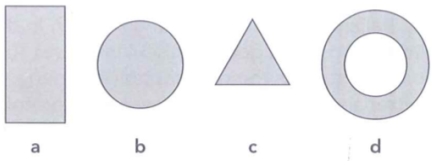
Mass uniformly distributed & regularly shaped:

Otherwise:



Exercise 4.h

Find the center of gravity of these laminar shapes.



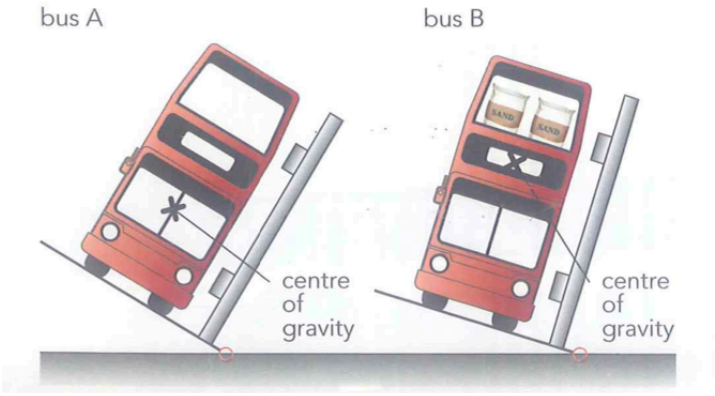
Back to the question above, can you summarize what kind of objects tend to be stable/ unstable?

Stable: lower center of mass, wide base
Unstable: higher center of mass, marrow base

Exercise 4.i

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.

i. 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.