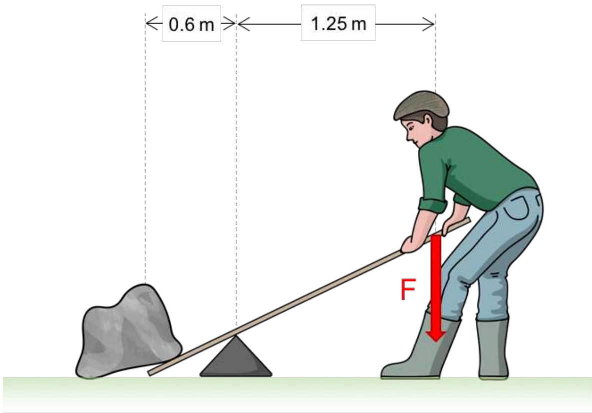
0 1 A man is using a lever to lift a heavy rock, as shown below.



0 1 . 1 The mass of the rock is 70 kg. Calculate its weight. Take g = 9.8 N/kg.

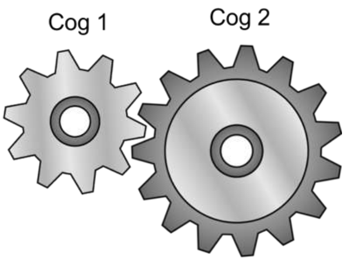
W = m g = 70 × 9.8 = **686 N**

0 1 . 2 Determine the minimum downwards force (F) which the man must apply to the end of the lever to lift the rock.

Theory leading to below equation: in equilibrium, ACW moment exerted by rock = CW moment exerted by man about pivot. If the man applies a force greater than the equilibrium force (F), there will be a net (resultant) CW moment about the pivot and the rock will be pushed upwards.

F × 1.25 = 686 × 0.6
1.25 F = 411.6
F = 411.6 ÷ 1.25 = **329 N** (to nearest N)

0 2 The below diagram shows two of the cogs which are used inside an antique watch. Information on each cog is also displayed below.



Cog number	Number of teeth	Radius (mm)
1	10	5.0
2	15	7.5

0 2 . 1 A force of 0.1 N is applied to cog 1. Calculate the moment of this force about the centre of the cog. Include an appropriate unit with your answer.

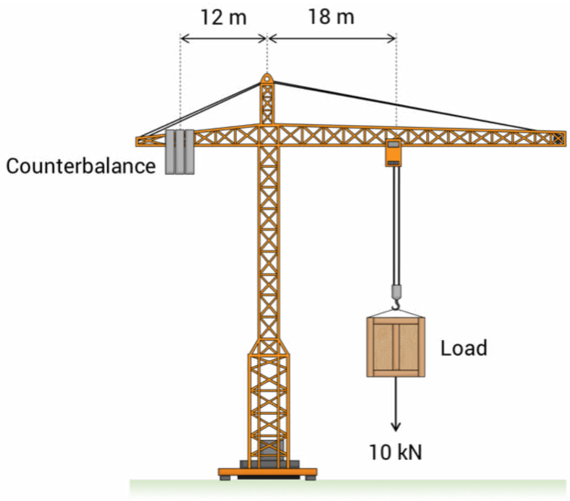
Either M = F d = 0.1 × 0.005 = **0.0005 N m** (newton-meters)

or M = F d = 0.1 × 5 = **0.5 N mm** (newton-millimeters)

02.2 Show that the moment (turning effect) produced about cog 2 as a result of this force is 50% larger than that produced about cog 1.

(By Newton's third law) force on cog 2 = force on cog 1 = 0.1 N.
Moment about cog 2, M = F d = 0.1 × 0.0075 = 0.00075 N m (0.75 N mm) which is 50% greater than previous answer of 0.0005 N m (0.5 N mm).

03 A crane is being used to lift a 10 kN load on a building site.



03.1 State the Principle of Moments.

For an object to be in (rotational) equilibrium [1], the total clockwise moment (about any pivot) [1] must be equal to the total anticlockwise moment (about the same pivot) [1].

03.2 Calculate the **mass** of counterbalance required for the above crane to be in equilibrium. You may neglect the weight of the crane in your calculation, and should take the value of g to be 9.8 N/kg.

Taking moments about base of crane:
(Total) ACW moment = (total) CW moment
W × 12 = 10,000 × 18 (W = weight of counterbalance)
W = 15,000 N

So mass, m = W ÷ g = 15,000 ÷ 9.8 = **1531 kg** (to nearest kilogram)

03.3 If the load is moved much closer to the base of the crane, the counterbalance might need to be adjusted. Suggest a reason why.

If the load is moved closer to the base of the crane, the clockwise moment it exerts (about the base of the crane) will decrease (M = F d) [1]. Unless the counterbalance is adjusted (either decreased in mass or moved closer to the base) there will then be a net (resultant) anticlockwise moment (about the base of the crane) which may damage the crane or cause it to topple over [1].