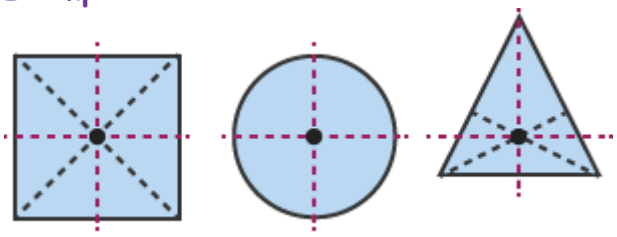

Centre of mass:

Definition: Centre of mass of an object is a point at which the entire mass of an object is supposed to be concentrated.

Centre of mass for symmetric objects:

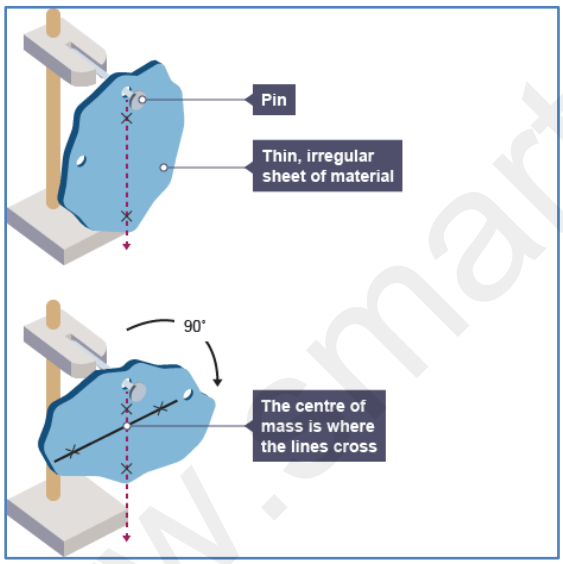
The centre of mass for a symmetrical object is where the axes of their symmetry cross each other

Example:



Centre of mass for asymmetrical objects:

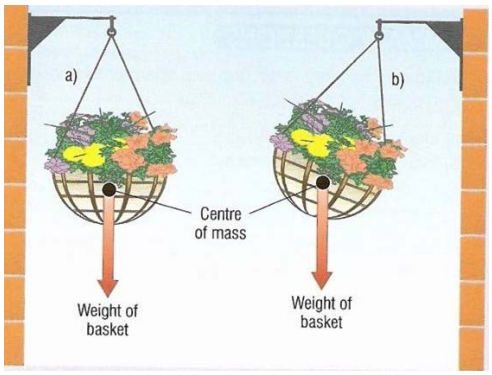
The centre of mass for an irregular shaped, non-symmetrical object is found in a different way.



1. Drill a small hole in the object and hang it up so that it is free to swing without obstruction.
2. Hang a plumb line (a piece of string with a weight hanging from it) from the same suspension point. This lets you mark the vertical line directly below the suspension point.
3. Drill another hole at a different location within the object.
4. Again hang a plumb line to determine the vertical and mark it on.
5. The point at which the two marked lines cross is the centre of mass

---

Center of mass of suspended objects:

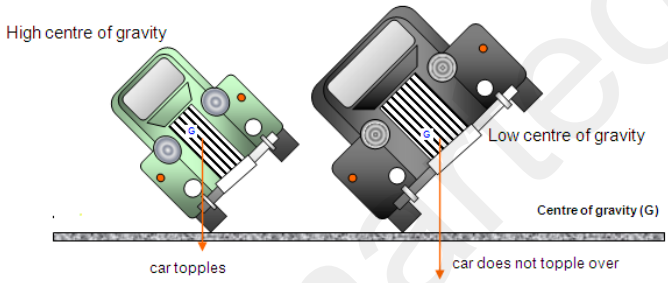


For suspended objects , the centre of mass lies exactly below the point of suspension of the objects.

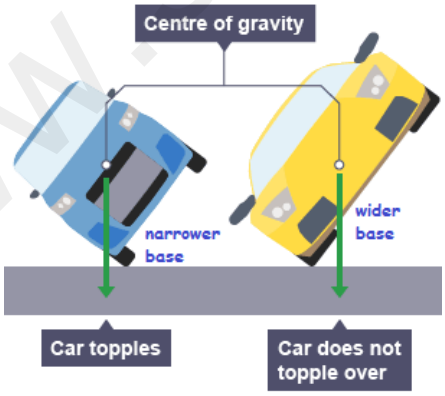
Stability and centre of mass:

The stability of an object can be increased by:

- Lowering its center of mass (center of gravity)



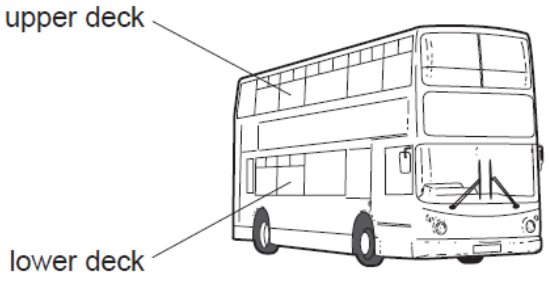
- Widening its base(so that the centre of mass falls within the base line.)



Example:

8 Passengers are **not** allowed to stand on the upper deck of double-decker buses.

0625/12/O/N/09



Why is this?

A They would cause the bus to become unstable.

B They would cause the bus to slow down.

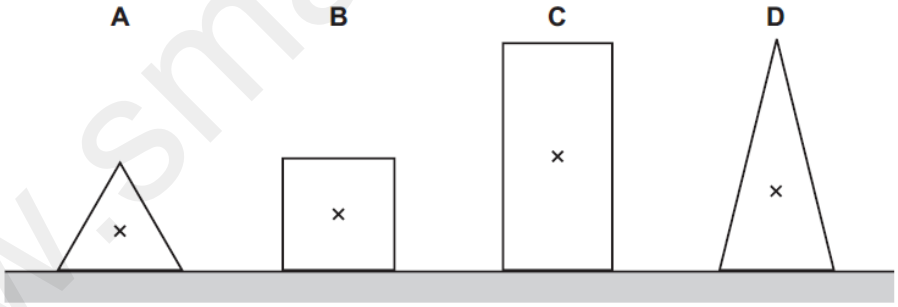
C They would increase the kinetic energy of the bus.

D They would lower the centre of mass of the bus.

46 The diagram shows sections of four objects of equal mass. The position of the centre of mass of each object has been marked with a cross.

0625/12/O/N/12

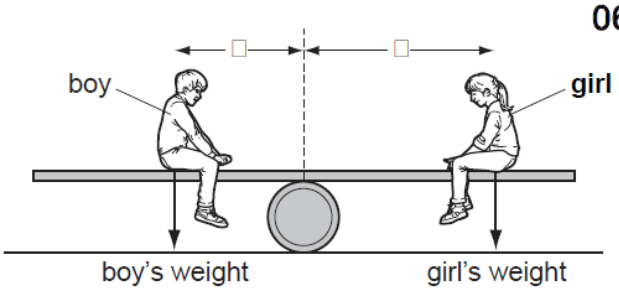
Which object is the most stable?



11 A see-saw is made by resting a long plank of wood with its centre of mass on a barrel.

A boy sits on one side of the barrel and a girl sits on the other side so that the see-saw is balanced.

0625/12/O/N/12



Which statement **must** be true?

A boy's weight = girl's weight

B distance *x* = distance *y*

C total downward force = total moment about the barrel

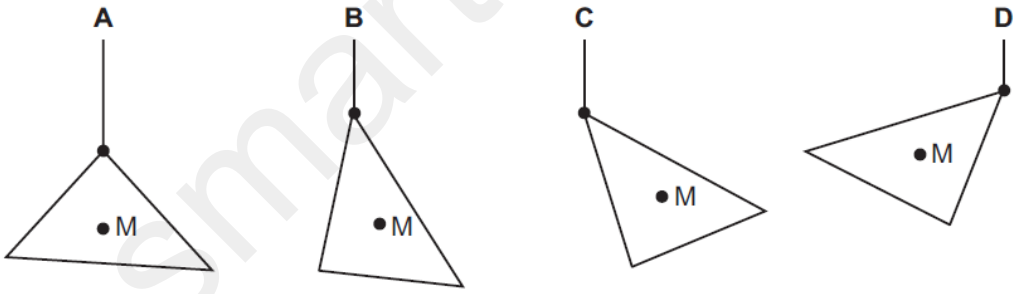
D resultant force and resultant moment are both zero

---

8 A piece of card has its centre of mass at M.

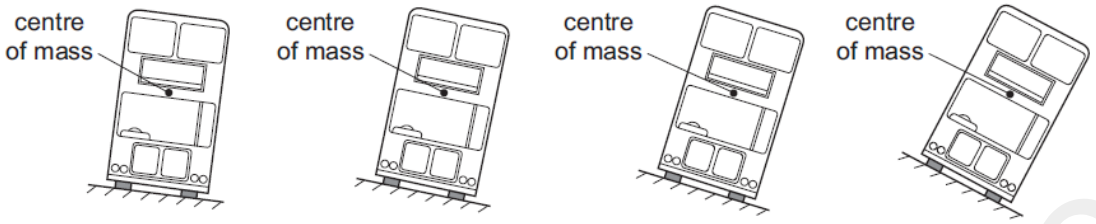
0625/01/M/J/04

Which diagram shows how it hangs when suspended by a thread?



---

8 The diagram shows four models of buses placed on different ramps. **0625/01/M/J/06**



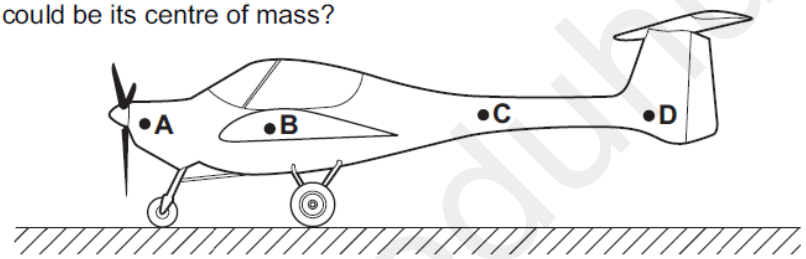
How many of these models will fall over?

A 1 **B** 2 **C** 3 **D** 4

---

9 A light aircraft stands at rest on the ground. It stands on three wheels, one at the front and two further back. **0625/01/M/J/07**

Which point could be its centre of mass?

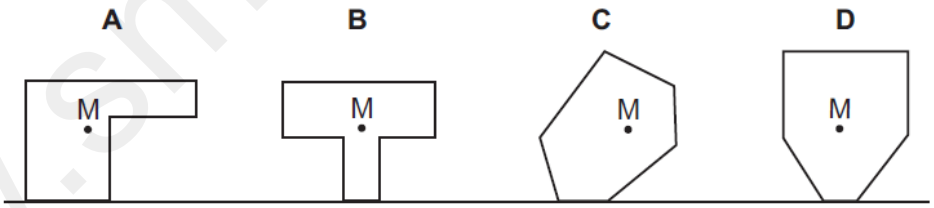


---

9 The diagram shows four objects standing on a flat surface. **0625/01/M/J/08**

The centre of mass of each object is marked M.

Which object will fall over?



APPLICATION QUESTIONS-EXTENDED THEORY

2 Fig. 2.1 shows a mobile bird sculpture that has been created by an artist.

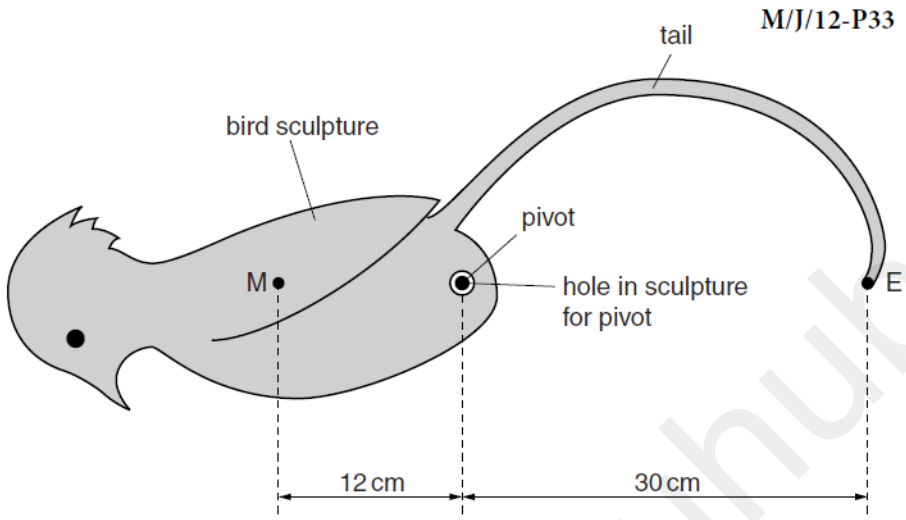


Fig. 2.1

M is the centre of mass of the bird sculpture, including its tail (but not including the counter-weight that will be added later). The mass of the bird and tail is 1.5 kg.

The bird sculpture is placed on a pivot.

The artist adds the counter-weight at the end E of the tail so that the bird remains stationary in the position shown.

(a) Calculate the mass of the counter-weight.

mass = ... [2]

(b) The centre of mass of the sculpture with counter-weight is at the pivot.

Calculate the upward force acting at the pivot.

force = ... [1]

(c) The sculpture is rotated clockwise to the position shown in Fig. 2.2. It is held still, then carefully released.

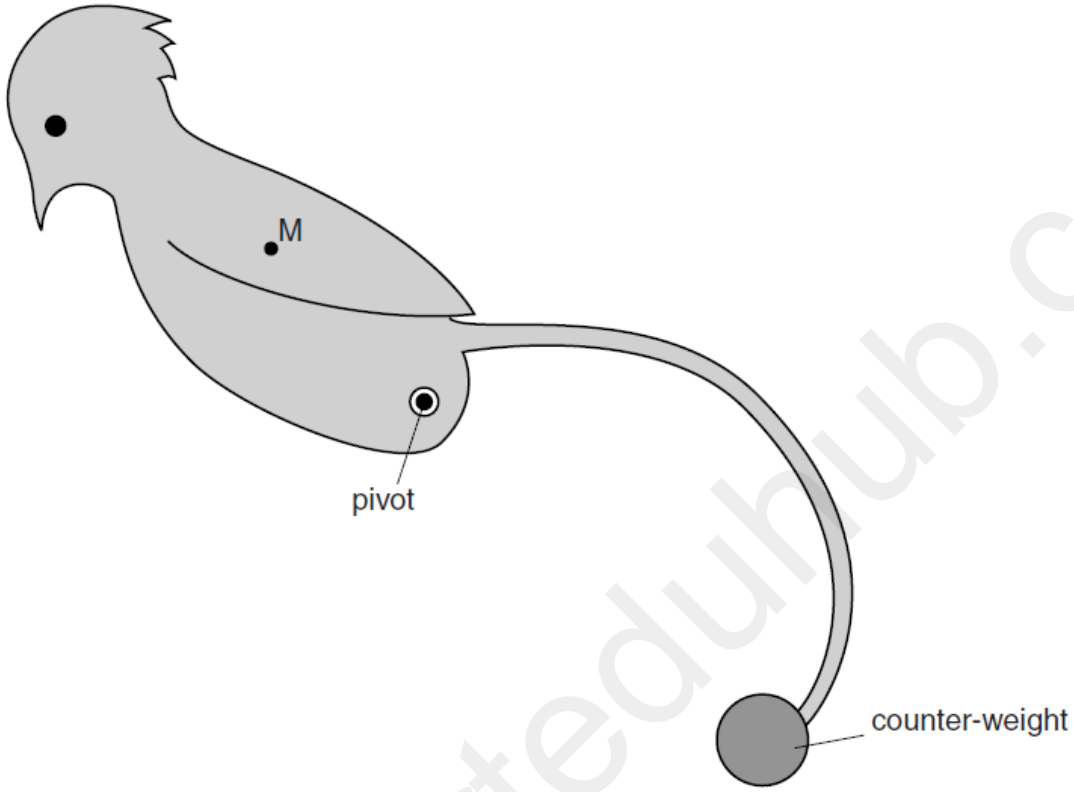


Fig. 2.2

(i) State whether the sculpture will stay in that position, rotate further clockwise or rotate back anticlockwise.

.....

.....

(ii) Explain your answer to **(i)**.

.....

.....

.....

.....

[3]

[Total: 6]

3 A metre rule balances when the 50 cm mark is directly above a pivot. M/J/14-P33

(a) State where in the rule its centre of mass is located.

.....

..... [1]

(b) Fig. 3.1 shows an apple and a 0.40 N weight placed on the rule so that the rule remains balanced at the 50 cm mark.

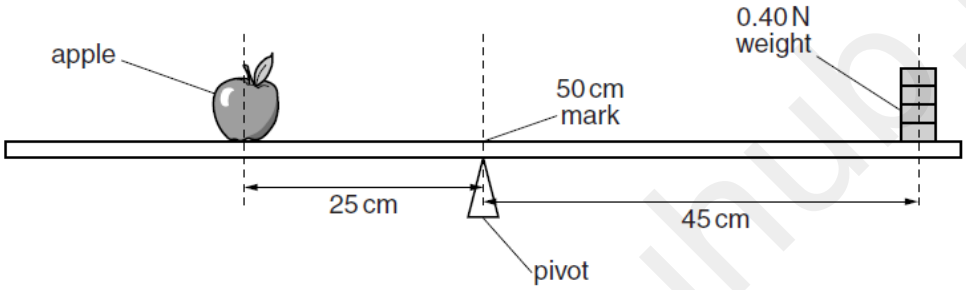


Fig. 3.1 (not to scale)

The centre of mass of the apple is 25 cm from the pivot and the centre of mass of the weight is 45 cm from the pivot.

Calculate

(i) the weight of the apple,

weight = ... [2]

(ii) the mass of the apple.

mass = ... [1]

(c) The apple is not moved. The weight is removed from the rule and the pivot is moved to the left until the rule balances as shown in Fig. 3.2.

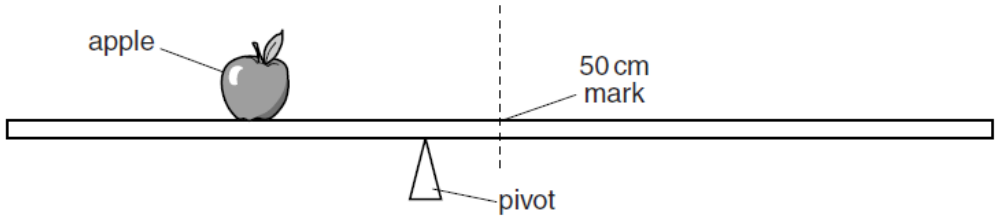


Fig. 3.2 (not to scale)

(i) Explain why the arrangement in Fig. 3.2 balances.

.....

.....

..... [2]

(ii) The pivot in Fig. 3.2 is closer to the 50 cm mark than to the centre of mass of the apple.

Compare the weight of the rule to the weight of the apple.

.....

..... [1]

[Total: 7]

3 **(a)** State the two conditions required for the equilibrium of a body acted upon by a number of forces.

O/N/11-P31

1. .....

.....

2. .....

.....[2]

(b) Fig. 3.1 shows a diagram of an arm with the hand holding a weight of 120 N.

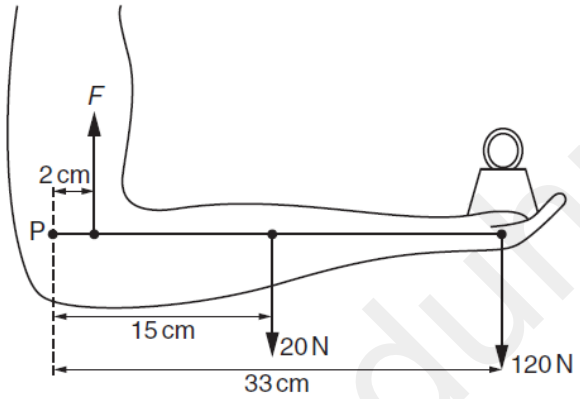


Fig. 3.1

The 20 N force is the weight of the forearm, acting at its centre of mass. *F* is the force in the muscle of the upper arm. P is the point in the elbow about which the arm pivots. The distances of the forces from point P are shown.

(i) By taking moments about point P, calculate the force *F*.

force *F* = ...[3]

(ii) A force acts on the forearm at point P. Calculate this force and state its direction.

force = ...

direction = ...[2]

[Total: 7]

4 **(a)** State what is meant by the *centre of mass* of a body. **O/N/12-P31**

.....

.....

..... [1]