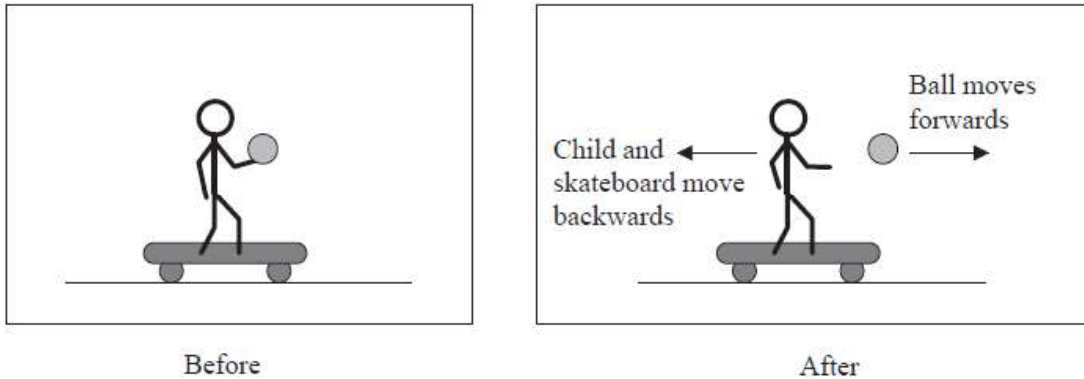Q1.

A child is standing on a skateboard and both are stationary. The child throws a ball forward at a high velocity and the child and the skateboard move backwards at a lower velocity.

Before   After

Explain, in terms of momentum, why the child and the skateboard move backwards at a lower velocity.

(4)

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(Total for question = 4 marks)

Q2.

Trolleys X and Y of masses *m* and 3*m* respectively are travelling at the same speed towards each other. The trolleys collide and move off together.


Which of the following statements is correct?

☐ **A** The force of X on Y during the collision is greater than the force of Y on X.

☐ **B** The force of X on Y during the collision is less than the force of Y on X.

☐ **C** The speed of X after the collision is greater than *v*.

☐ **D** The speed of X after the collision is less than *v*.

(Total for question = 1 mark)

Q3.

Popcorn kernels contain water. When heated, the water turns to steam. The kernel 'pops' and moves upwards.
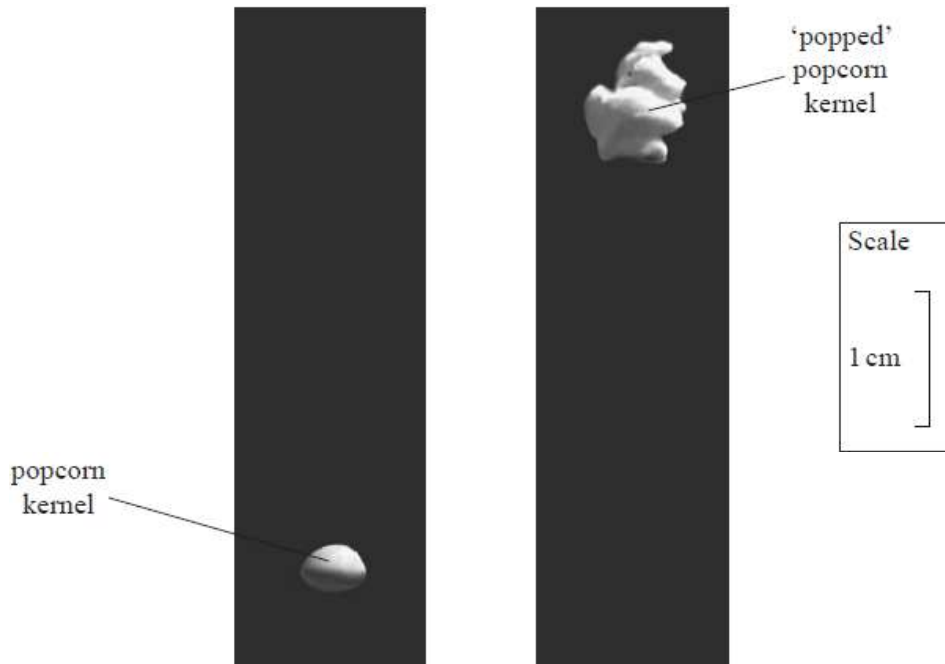
(a) The photographs above show a popcorn kernel just before popping and at the maximum height after popping. The time between the two photographs was 83 ms.

(i) Determine the maximum height after popping.

(2)

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Maximum height = ...

(ii) Calculate the initial speed of the 'popped' popcorn kernel.

(3)

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Initial speed = ...

(b) The average water content in a popcorn kernel is 14% of the total mass of the kernel.

A kernel is heated until it pops. Steam is ejected downwards, and the popped kernel moves upwards with an initial speed of 1.5 m s^{-1}.

Calculate the speed at which the steam is ejected.

total mass of unpopped kernel = 0.11 g

(4)

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Speed = ...

(Total for question = 9 marks)

Q4.

P and Q are identical spheres. Sphere P moves along a smooth horizontal surface and collides with sphere Q, which is initially stationary.
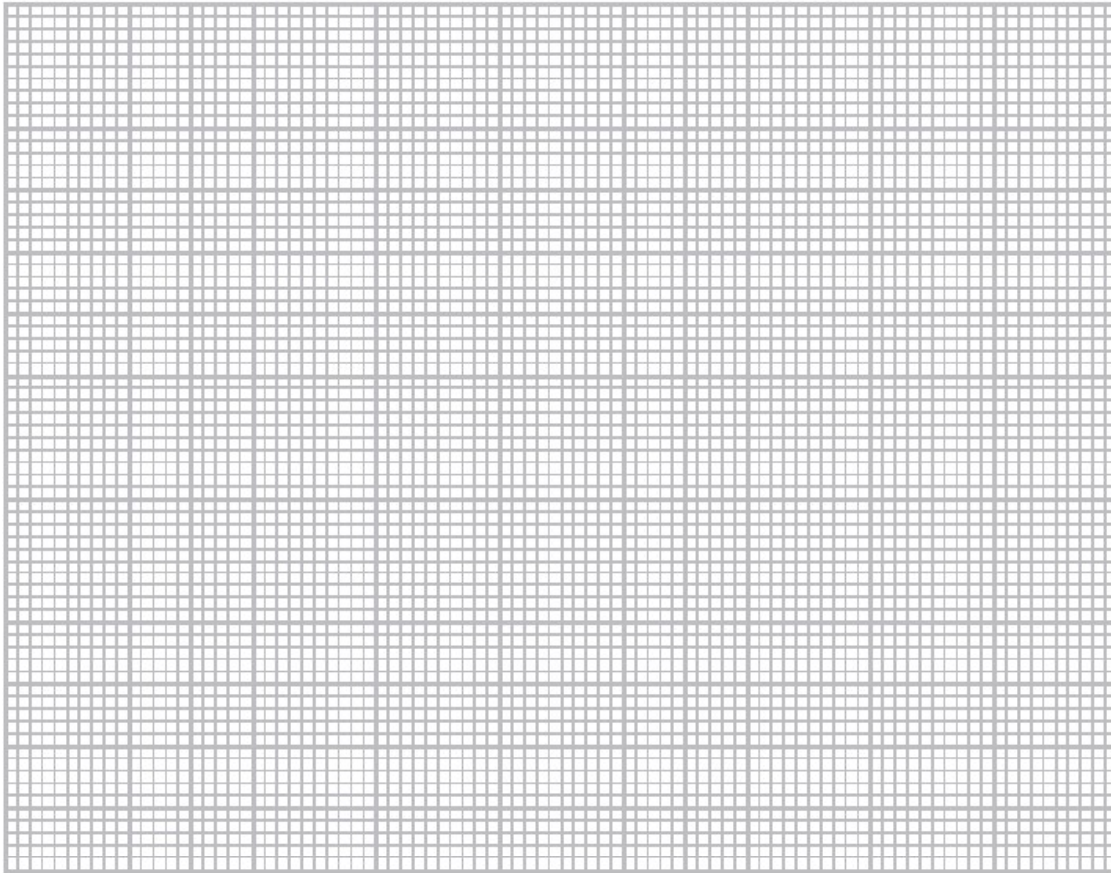
After the collision:

- sphere P moves off with a momentum of 0.096 kg m s^{-1} in a direction of 15° to its initial direction.
- sphere Q moves off with a momentum of 0.14 kg m s^{-1} in a direction of 10° as shown.

before the collision   after the collision
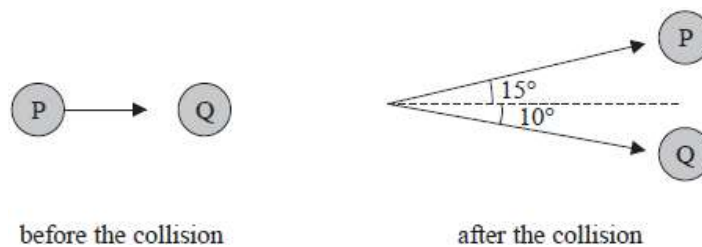
(a) Use a scaled vector diagram to show that the magnitude of the total momentum of spheres P and Q after the collision is about 0.2 kg m s^{-1}.

(4)

Total momentum of spheres P and Q after the collision = ...

(b) State the principle of conservation of linear momentum.

(2)

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(c) Calculate the initial velocity of sphere P.

mass of sphere P = 0.12 kg

(2)

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Initial velocity of sphere P = ...
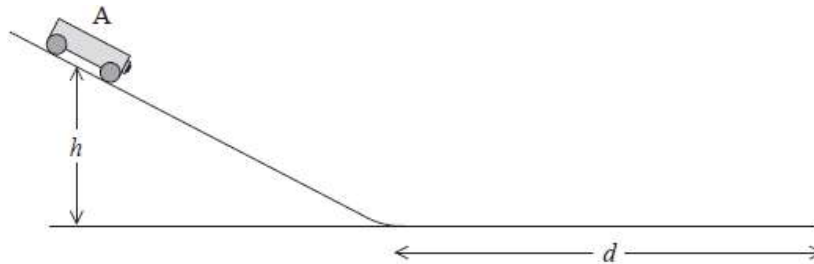
(Total for question = 8 marks)

Q5.

Which of the following quantities has the SI base units $kg\ m^2\ s^{-3}$?

☐ **A** force

☐ **B** momentum

☐ **C** power

☐ **D** work done

(Total for question = 1 mark)

Q6.

A student set up the apparatus shown.

(a)   When released from a height h, trolley A ran down the slope and then continued to move horizontally. On the horizontal part of the track a frictional force F brought the trolley to rest over a short distance d. The trolley has a mass m. The student measured d for a range of heights h.

The student plotted the following graph of d against h.
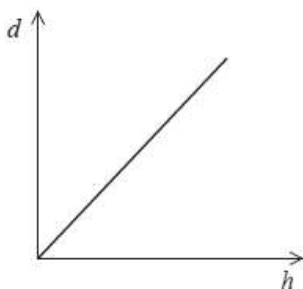
Derive an expression for the gradient of the graph, in terms of F, m and g.

(2)

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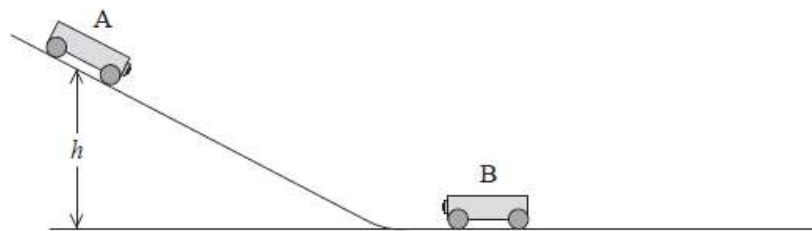..

(b) In a second experiment, an identical trolley B was placed at rest at the bottom of the slope. When trolley A was released as before, it rolled down and collided with trolley B. After the collision the two trolleys joined together and moved off to the right with a velocity v.

The student predicted that, provided friction was ignored, $v = \sqrt{\dfrac{gh}{2}}$.

Assess whether the student was correct.

(4)

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(Total for question = 6 marks)