PHYSICAL SCIENCES – GRADE 12
VERTICAL PROJECTILE MOTION IN 1D

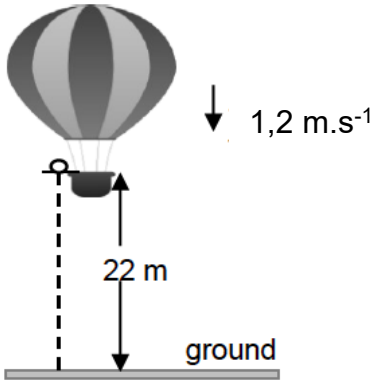
Lesson	Date	Topic
2	14 February 2025	Vertical projectile motion: Part 1
3	21 February 2025	Vertical projectile motion: Part 2

Definitions (as per DBE examination guidelines 2021)

Term/ Concept	Definition/ Description
Projectile	An object which has been given an initial velocity and then it moves under the influence of gravitational force only.
Free fall	Motion during which the only force acting on an object is the gravitational force.

Question 5

A hot-air balloon moves vertically downwards at a constant velocity of 1,2 $m.s^{-1}$. When it reaches a height of 22 m from the ground, a ball is dropped from the balloon.



Assume that the dropping of the ball has no effect on the speed of the hot-air balloon. Ignore air friction for the motion of the ball.

5.1 Is the hot-air balloon in free fall? Give a reason for your answer.

5.2 Calculate the time it takes for the ball to hit the ground after it is dropped.

When the ball lands on the ground, it is in contact with the ground for 0,3 s and then it bounces vertically upwards with a speed of 15 $m.s^{-1}$.

5.3 Calculate how high the balloon is from the ground when the ball reaches its maximum height after the first bounce.

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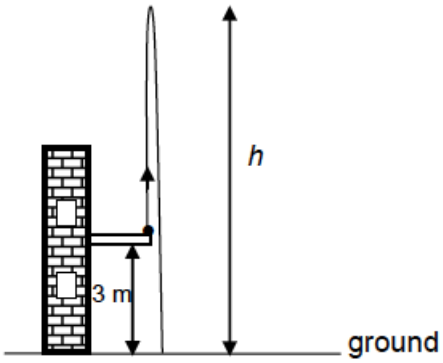
QUESTION 3 (Start on a new page.)

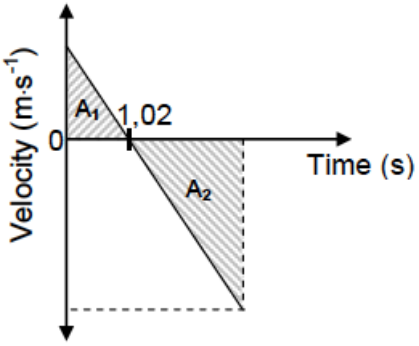
A ball, of mass 0,06 kg, is thrown vertically upwards from the balcony of a building, 3 m above the ground. The ball reaches a maximum height *h* above the ground, as shown in the diagram below.

Ignore the effects of air resistance.



3.1 Name the force acting on the ball while it is in free fall. (1)

The velocity-time graph below represents the motion of the ball from the instant it is thrown upwards until it hits the ground.



3.2 Write down the acceleration of the ball at time t = 1,02 s. (2)

3.3 Consider the areas $\mathbf{A_1}$ and $\mathbf{A_2}$ shown in the graph above. Write down the numerical value represented by the DIFFERENCE in areas $\mathbf{A_1}$ and $\mathbf{A_2}$. (1)

3.4 Calculate the:

3.4.1 Speed at which the ball is thrown upwards (3)

3.4.2 Height *h* (4)

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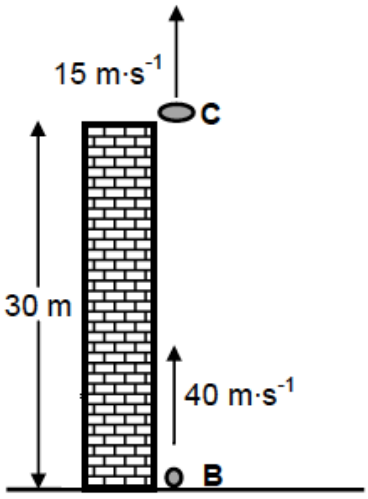
QUESTION 3 (Start on a new page.)

A small disc, **C**, is thrown vertically upwards at a speed of 15 $m \cdot s^{-1}$ from the edge of the roof of a building of height 30 m. AFTER 0,5 s, a small ball **B** is shot vertically upwards from the foot of the building at a speed of 40 $m \cdot s^{-1}$ in order to hit disc **C**.

Ignore the effects of air resistance.



3.1 Explain the term *projectile*. (2)

3.2 Calculate the:

3.2.1 Time taken by disc **C** to reach its maximum height (3)

3.2.2 Maximum height above the ground reached by disc **C** (4)

3.3 Calculate the time from the moment that disc **C** was thrown upwards until the time ball **B** hits the disc. (6)

3.4 On the same set of axes, sketch graphs of velocity versus time for disk **C** and ball **B** from the moment that disc **C** was thrown upwards until ball **B** hits disc **C**.

Label the graph for ball **B** as B and the graph for disc **C** as C.

Clearly indicate the following on the graphs:

- The initial velocities of ball **B** and disc **C**
- The time at which ball **B** was shot upward
- The time at which disc **C** reaches its maximum height
- The time at which ball **B** hits disc **C**

(5)
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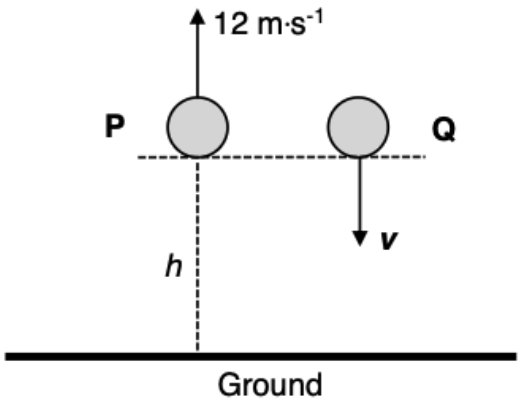
3.2 Stone **P** is projected vertically upwards at a speed of 12 $m \cdot s^{-1}$ from a height *h* ABOVE THE GROUND. Ignore the effects of air resistance.

3.2.1 Explain what is meant by a *projectile*. (2)

3.2.2 Calculate the time taken for **P** to reach its maximum height. (3)

At the same instant that **P** is projected UPWARDS, stone **Q** is thrown vertically DOWNWARDS from the same height at an UNKNOWN SPEED *v*. Refer to the diagram. When **P** reaches its maximum height, the speed of **Q** is 3*v*.



3.2.3 Calculate the speed, *v*, with which **Q** is thrown downwards. (4)

3.2.4 At the instant **P** passes its initial position on its way down, **Q** hits the ground. Calculate the height *h*. (4)

3.2.5 Sketch VELOCITY-TIME GRAPHS for the complete motion of **P** and **Q** on the same set of axes. Clearly label your graphs as **P** and **Q**.

Show the following on the graphs:
- The time taken for **P** to reach its maximum height.
- The velocity with which **Q** is thrown downwards. (4)

MOTION

$v_f = v_i + a\Delta t$	$\Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2$ OR $\Delta y = v_i\Delta t + \frac{1}{2}a\Delta t^2$
$v_f^2 = v_i^2 + 2a\Delta x$ OR $v_f^2 = v_i^2 + 2a\Delta y$	$\Delta x = \left(\frac{v_i + v_f}{2}\right)\Delta t$ OR $\Delta y = \left(\frac{v_i + v_f}{2}\right)\Delta t$