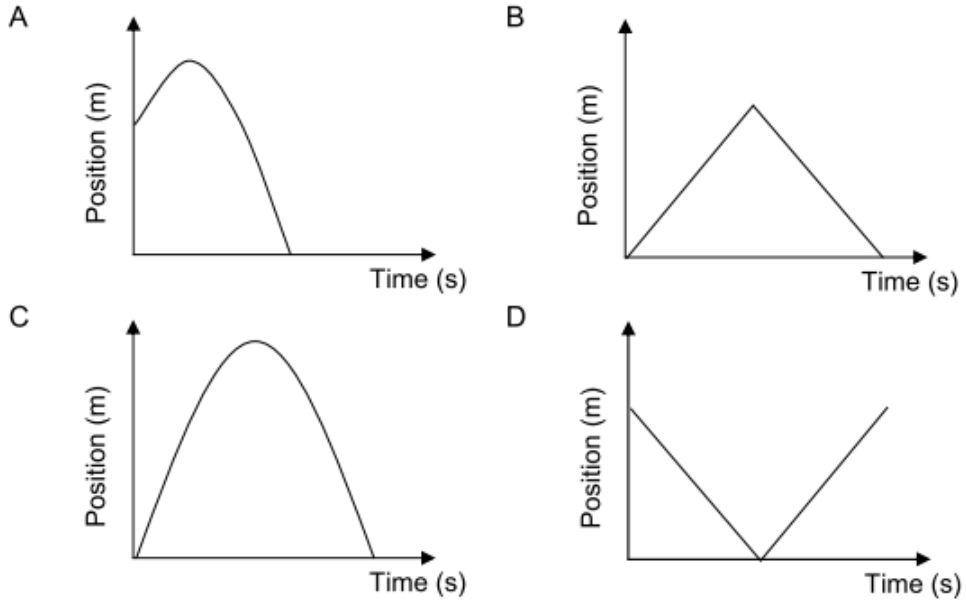
GRADE 12 REVISION 2013
MECHANICS: VERTICAL PROJECTILE MOTION

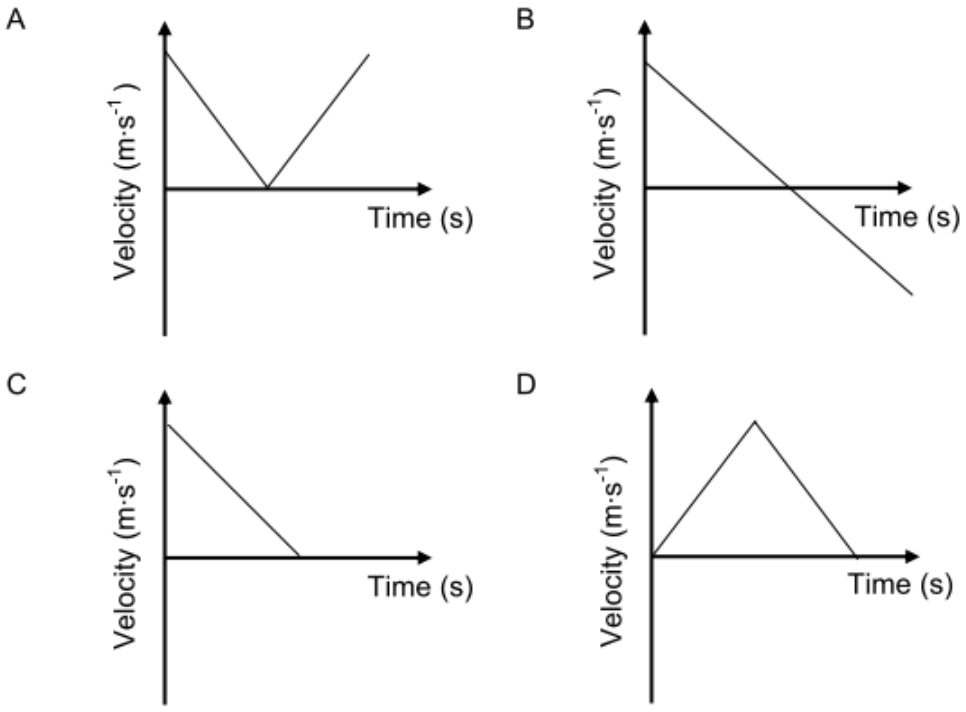
MULTIPLE-CHOICE QUESTIONS

1. A stone is thrown vertically upwards and returns to the thrower's hand after a while. Which ONE of the following position-versus-time graphs best represents the motion of the stone?



(2)

2. A stone is thrown vertically upwards and returns to the thrower's hand after a while. Which ONE of the following velocity-time graphs best represents the motion of the stone?



(2)

3. An object projected vertically upwards reaches its maximum height and returns to its original point of projection. Ignoring the effects of friction, the direction of the acceleration of the object during its motion is

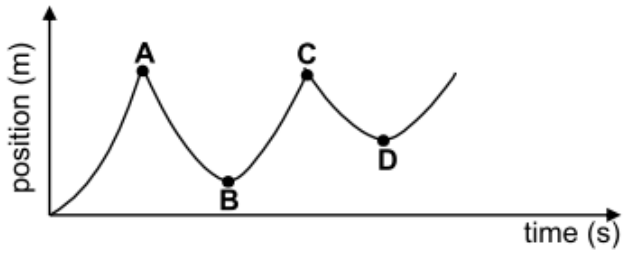
A always vertically downwards.

B first vertically upwards and then vertically downwards.

C first vertically downwards and then vertically upwards.

D always vertically upwards. (2)

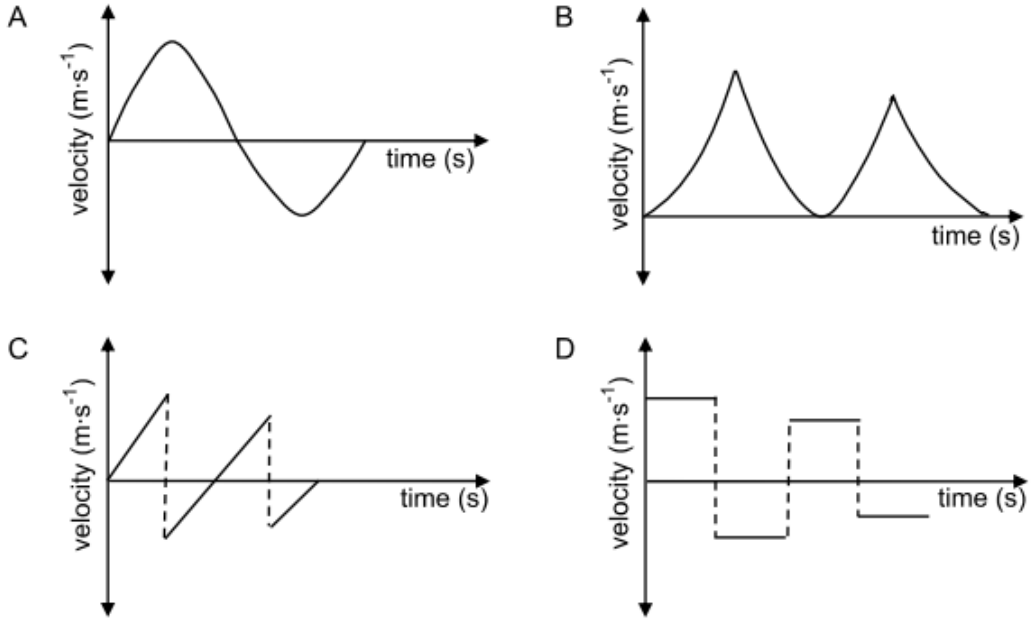
4. A ball is released from rest from a certain height above the floor and bounces off the floor a number of times. The position-time graph below represents the motion of the bouncing ball from the instant it is released from rest.



Neglecting air resistance, which point (**A**, **B**, **C** or **D**) on the graph represents the position-time coordinates of the maximum height reached by the ball after the SECOND bounce?

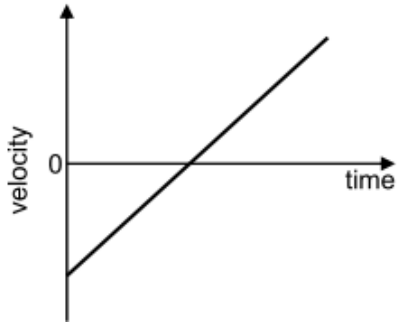
A A
B B
C C
D D

5. A ball is released from rest from a certain height above the floor and bounces off the floor a number of times. Ignore the effects of air resistance. Which ONE of the following velocity-time graphs best represents the motion of the ball?



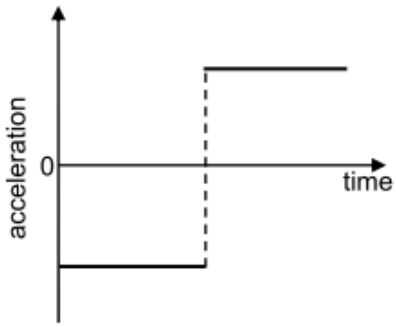
(2)

6. The velocity-time graph below represents the motion of an object.

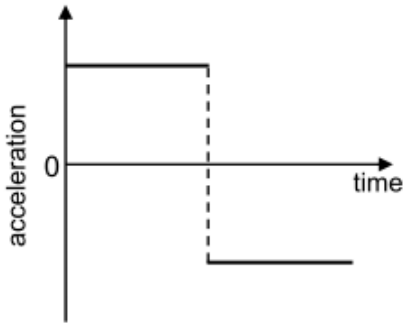


Which ONE of the following graphs represents the corresponding acceleration-time graph for the motion of this object?

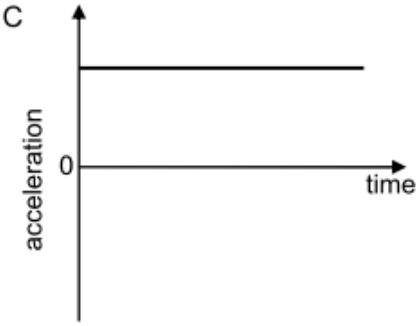
A



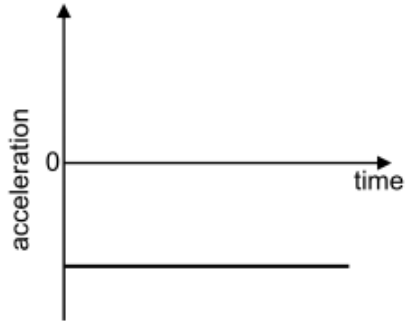
B



C

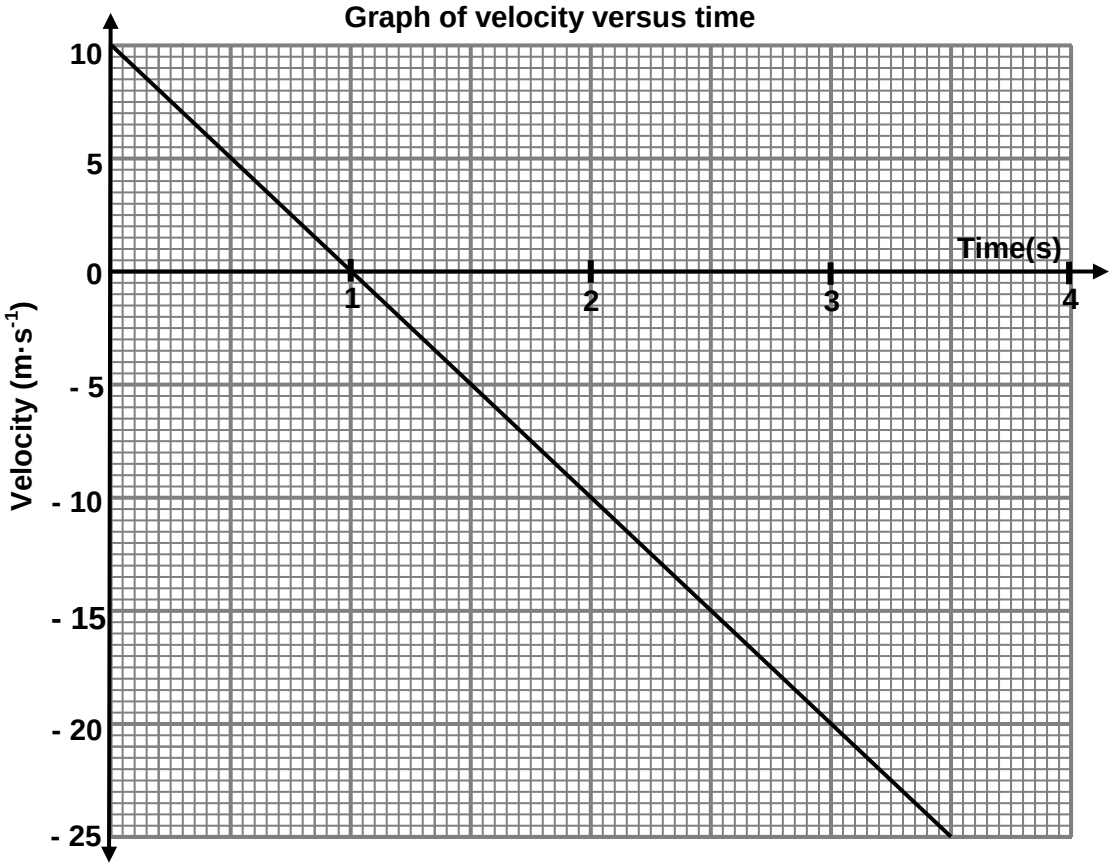


D



STRUCTURED QUESTIONS

1. A boy stands at the edge of a high cliff. He throws a stone vertically upwards with an initial velocity of 10 m·s^{-1}. The stone strikes the ground at a point below the cliff after 3,5 s. The velocity-time graph below was obtained from **measurements** made during the motion of the stone.



Use the information on the graph to answer the following questions:

1.1 Calculate the acceleration of the stone between times t = 2 s and t = 3 s. (3)

1.2 At which time(s) is the stone moving at a speed of 5 m·s^{-1}? (2)

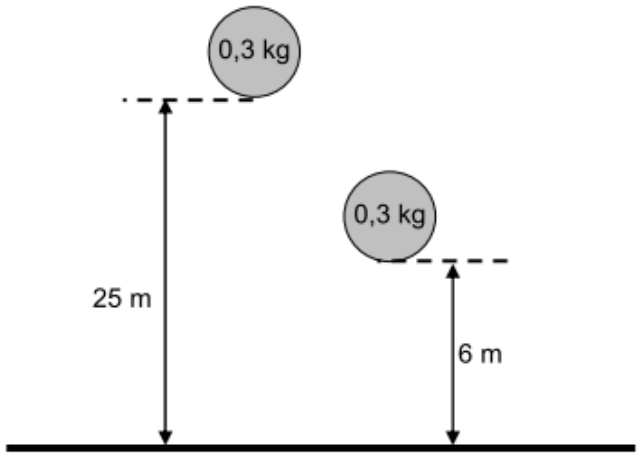
1.3 After how many seconds does the stone reach its highest point? (1)

1.4 Determine the height of the cliff from which the stone was thrown. (4)

1.5 Using the top of the cliff as the initial position of the stone, sketch the position-time graph (displacement-time graph) for the motion of the stone **from its highest point until it reaches the ground**. Only indicate relevant time values on the x-axis. (3)

[13]

2. The roof of a tall building is 25 m above the ground. A rigid ball of mass 0,3 kg falls freely when dropped from the roof. It strikes the concrete floor on the ground with velocity v_1. It bounces to a maximum vertical height of 6 m. The ball was in contact with the floor for 0,9 s. Ignore the effects of friction.



2.1 Calculate the velocity v_1 when the ball first hits the floor. (3)

2.2 Calculate the impulse of the ball as a result of the collision. (7)

2.3 Calculate the magnitude of the net force exerted on the ball. (3)

2.4 Using the ground as zero reference, draw a sketch graph of position (displacement) versus time for the motion of the ball from its original height until it reaches its second maximum height. Indicate the relevant position values on the y-axis. (4)

2.5 The rigid ball is now replaced with a softer ball of the same mass and volume as the rigid ball. It is then dropped from the same height onto the concrete floor. Will the ball reach the SAME, GREATER or LESSER height compared to the previous ball? Use principles of physics to explain your answer. (3)

[20]

3. The following extract comes from an article in a school newspaper.

THE LAWS OF PHYSICS ARE ACCURATE!

Two construction workers, Alex and Pete, were arguing about whether a smaller brick would hit the ground quicker than a larger brick when both are released from the same height.

Alex said that the larger brick should hit the ground first. Pete argued that the smaller brick would hit the ground first.

3.1 Are their statements correct? Give a reason for your answer. (3)

3.2 A group of Physical Sciences learners decide to test Alex's and Pete's hypotheses. They drop two bricks, one small and the other much larger, from one of the floors of the school building.

3.2.1 Write down TWO precautions they should take to ensure that the result is reliable. (2)

3.2.2 Give a reason why, despite all the necessary precautions, they might not get the correct result. (1)

3.3 In another experiment, the learners drop a brick **A** from a height of 8 m. After 0,6 s, they throw a second brick **B** downwards from the same height. Both bricks, **A** and **B**, hit the ground at the same time. Ignore the effects of friction and calculate the speed at which brick **B** was thrown. (7)

[13]

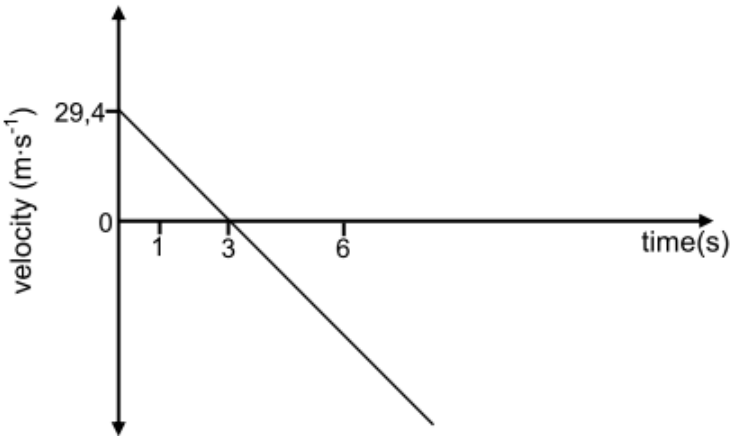
4. A supervisor, 1,8 m tall, visits a construction site. A brick resting at the edge of a roof 50 m above the ground suddenly falls. At the instant when the brick has fallen 30 m the supervisor sees the brick coming down directly towards him from above. Ignore the effects of friction and take the downwards motion as positive.

4.1 Calculate the speed of the brick after it has fallen 30 m. (3)

4.2 The average reaction time of a human being is 0,4 s. With the aid of a suitable calculation, determine whether the supervisor will be able to avoid being hit by the brick. (6)

[9]

5. A man fires a projectile **X** vertically upwards at a velocity of 29,4 $m \cdot s^{-1}$ from the EDGE of a cliff of height 100 m. After some time the projectile lands on the ground below the cliff. The velocity-time graph below (NOT DRAWN TO SCALE) represents the motion of projectile **X**. (Ignore the effects of friction.)



5.1 Use the graph to determine the time that the projectile takes to reach its maximum height. (A calculation is not required.) (1)

5.2 Calculate the maximum height that projectile **X** reaches above the ground. (4)

5.3 Sketch the position-time graph for projectile **X** for the period t = 0 s to t = 6 s. USE THE EDGE OF THE CLIFF AS ZERO OF POSITION.

Indicate the following on the graph:
- The time when projectile **X** reaches its maximum height
- The time when projectile **X** reaches the edge of the cliff (4)

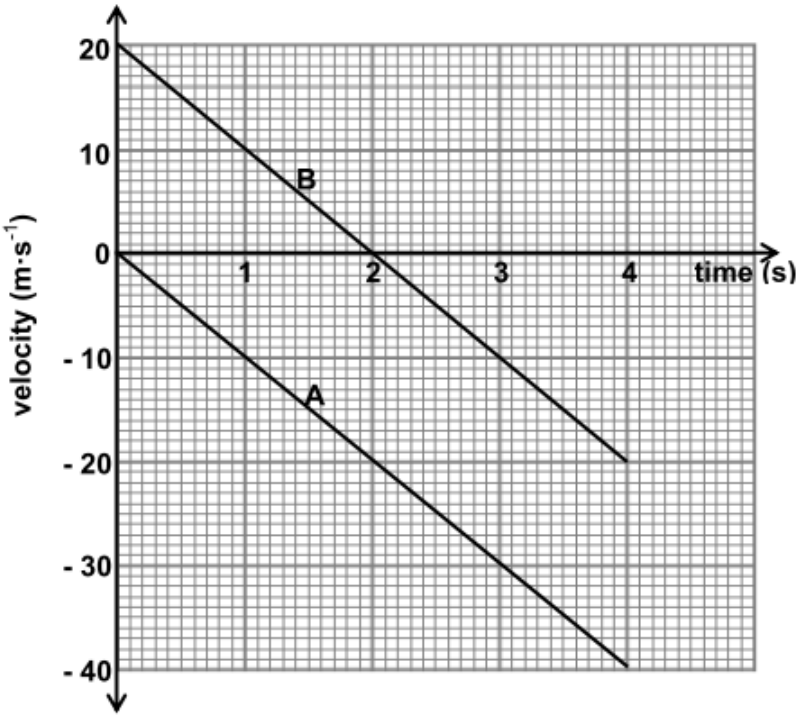
5.4 One second (1 s) after projectile **X** is fired, the man's friend fires a second projectile **Y** upwards at a velocity of 49 $m \cdot s^{-1}$ FROM THE GROUND BELOW THE CLIFF. The first projectile, **X**, passes projectile **Y** 5,23 s after projectile **X** is fired. (Ignore the effects of friction.)

Calculate the following:

5.4.1 The velocity of projectile **X** at the instant it passes projectile **Y** (5)

5.4.2 The velocity of projectile **X** RELATIVE to projectile **Y** at the instant it passes projectile **Y** (5)
[19]

6. The velocity-time graph shown below represents the motion of two objects, **A** and **B**, released from the same height. Object **A** is released from REST and at the same instant object **B** is PROJECTED vertically upwards. (Ignore the effects of friction.)



6.1 Object **A** undergoes a constant acceleration. Give a reason for this statement by referring to the graph. (No calculations are required.) (2)

6.2 At what time/times is the SPEED of object **B** equal to 10 $m \cdot s^{-1}$? (2)

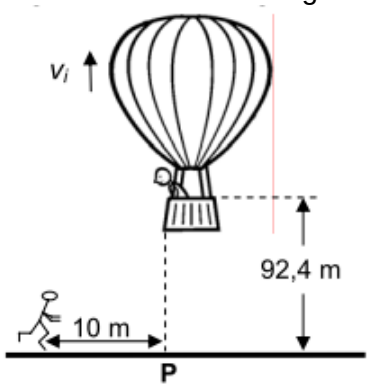
6.3 What is the velocity of object **A** relative to object **B** at t = 1 s? (3)

6.4 Object **A** strikes the ground after 4 s. USE EQUATIONS OF MOTION to calculate the height from which the objects were released. (3)

6.5 What physical quantity is represented by the area between the graph and the time axis for each of the graphs **A** and **B**? (2)

6.6 Calculate, WITHOUT USING EQUATIONS OF MOTION, the distance between objects **A** and **B** at t = 1 s. (5)
[17]

7. A hot-air balloon is moving vertically upwards at a constant speed. A camera is accidentally dropped from the balloon at a height of 92,4 m as shown in the diagram below. The camera strikes the ground after 6 s. Ignore the effects of friction.



7.1 At the instant the camera is dropped, it moves upwards. Give a reason for this observation. (1)

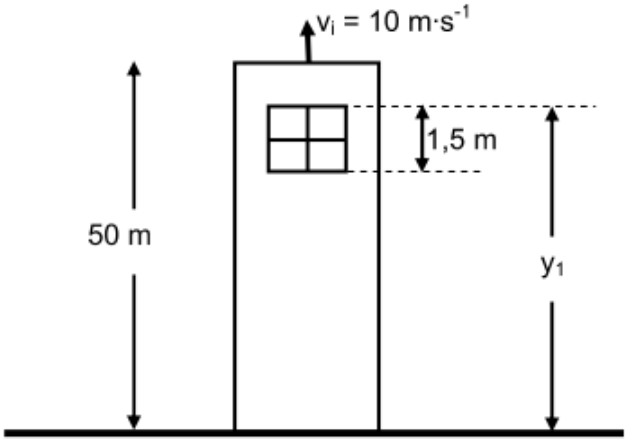
7.2 Calculate the speed v_i at which the balloon is rising when the camera is dropped. (4)

7.3 Draw a sketch graph of velocity versus time for the entire motion of the camera. Indicate the following on the graph:
- Initial velocity
- Time at which it reaches the ground (4)

7.4 If a jogger, 10 m away from point **P** as shown in the above diagram and running at a constant speed of 2 $m \cdot s^{-1}$, sees the camera at the same instant it starts falling from the balloon, will he be able to catch the camera before it strikes the ground? Use a calculation to show how you arrived at the answer. (5)

[14]

8. A stone is thrown vertically upward at a velocity of 10 $m \cdot s^{-1}$ from the top of a tower of height 50 m. After some time the stone passes the edge of the tower and strikes the ground below the tower. Ignore the effects of friction.



8.1 Draw a labelled free-body diagram showing the force(s) acting on the stone during its motion. (1)

8.2 Calculate the:

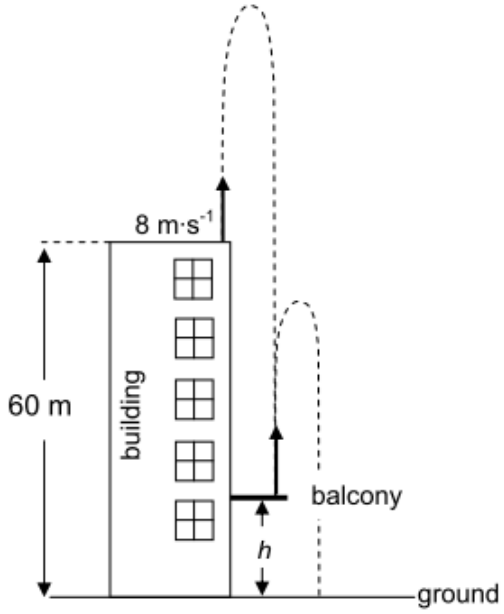
8.2.1 Time taken by the stone to reach its maximum height above the ground (4)

8.2.2 Maximum height that the stone reaches above the ground (4)

8.3 USING THE GROUND AS REFERENCE (zero position), sketch a position-time graph for the entire motion of the stone. (3)

8.4 On its way down, the stone takes 0,1 s to pass a window of length 1,5 m, as shown in the diagram above. Calculate the distance (y_i) from the top of the window to the ground. (7)
[19]

9. An object is projected vertically upwards at 8 $m \cdot s^{-1}$ from the roof of a building which is 60 m high. It strikes the balcony below after 4 s. The object then bounces off the balcony and strikes the ground as illustrated below. Ignore the effects of friction.



9.1 Is the object's acceleration at its maximum height UPWARD, DOWNWARD or ZERO? (1)

9.2 Calculate the:

9.2.1 Magnitude of the velocity at which the object strikes the balcony (4)

9.2.2 Height, *h*, of the balcony above the ground (5)

The object bounces off the balcony at a velocity of 27,13 $m \cdot s^{-1}$ and strikes the ground 6 s after leaving the balcony.

9.3 Sketch a velocity-time graph to represent the motion of the object from the moment it is projected from the ROOF of the building until it strikes the GROUND. Indicate the following velocity and time values on the graph:

- The initial velocity at which the object was projected from the roof of the building
- The velocity at which the object strikes the balcony
- The time when the object strikes the balcony
- The velocity at which the object bounces off the balcony
- The time when the object strikes the ground (6)

[16]

10. A ball of mass 0,2 kg is dropped from a height of 0,8 m onto a hard floor. It bounces to a maximum height of 0,6 m. The floor exerts a force of 50 N on the ball. Ignore the effects of friction.

10.1 Write down the magnitude and direction of the force that the ball exerts on the floor. (2)

10.2 Calculate the:

10.2.1 Velocity at which the ball strikes the floor (4)

10.2.2 Time that the ball is in contact with the floor if it bounces off the floor at a speed of 3,43 $m \cdot s^{-1}$. (4)

10.3 The ball takes 0,404 s from the moment it is dropped until it strikes the floor. Sketch a graph (not to scale) of position versus time representing the entire motion of the ball. USE THE GROUND AS ZERO REFERENCE. Indicate the following on the graph:

- Height from which the ball is dropped
- Height reached by the ball after the bounce
- Time at which the ball bounces off the floor (5)

[15]

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