

# 2.1 Motion

## Question Paper

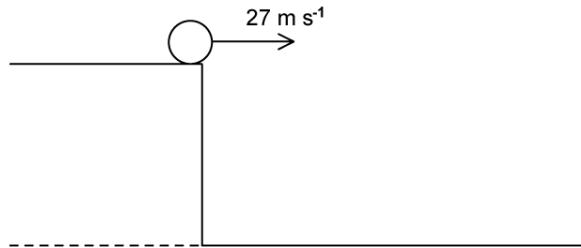
Course	DPIB Physics
Section	2. Mechanics
Topic	2.1 Motion
Difficulty	Medium

**Time allowed:** 80  
**Score:** /63  
**Percentage:** /100

### Question 1a

A ball is projected horizontally at  $27 \text{ m s}^{-1}$  from a vertical cliff. It travels a horizontal distance of 40 m before hitting the ground.

Assume that air resistance is negligible.



(a)

Calculate the vertical velocity of the ball just before it hits the ground.

[4 marks]

### Question 1b

(b)

Calculate the height of the cliff.

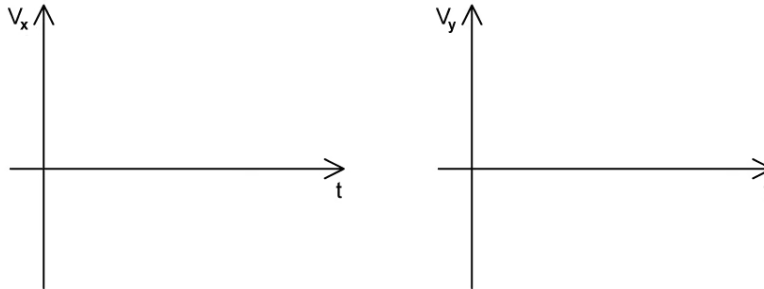
[2 marks]

### Question 1c

(c)

Sketch the graphs to show how the horizontal and vertical components of the velocity of the ball,  $v_x$  and  $v_y$ , change with time  $t$  just before the ball hits the ground.

Label any appropriate values on the axes.



[3 marks]

### Question 1d

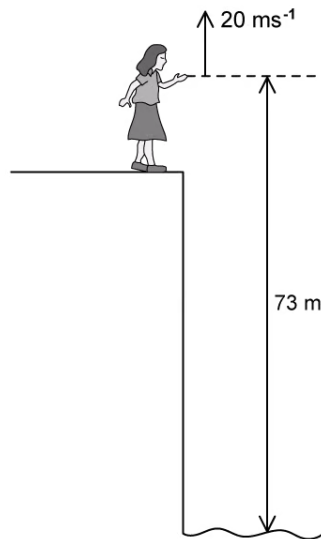
(d)

Calculate the resultant velocity of the ball just before it hits the ground.

[2 marks]

### Question 2a

Naomi stands on the edge of a vertical cliff and throws a stone vertically upwards.



The stone leaves her hand with a speed of  $20 \text{ m s}^{-1}$  at the instant her hand is 73 m above the surface of the sea. Air resistance is negligible.

(a)

Calculate the maximum height reached by the stone as measured from the point it was thrown.

[2 marks]

### Question 2b

(b)

Determine the time taken for the stone to pass by the point from which it was released.

[3 marks]

### Question 2c

(c)

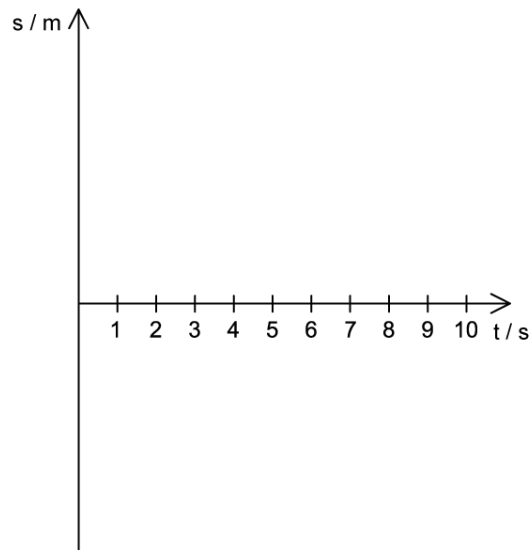
Calculate the time taken for the stone to land in the sea after leaving Naomi's hand.

[4 marks]

### Question 2d

(d)

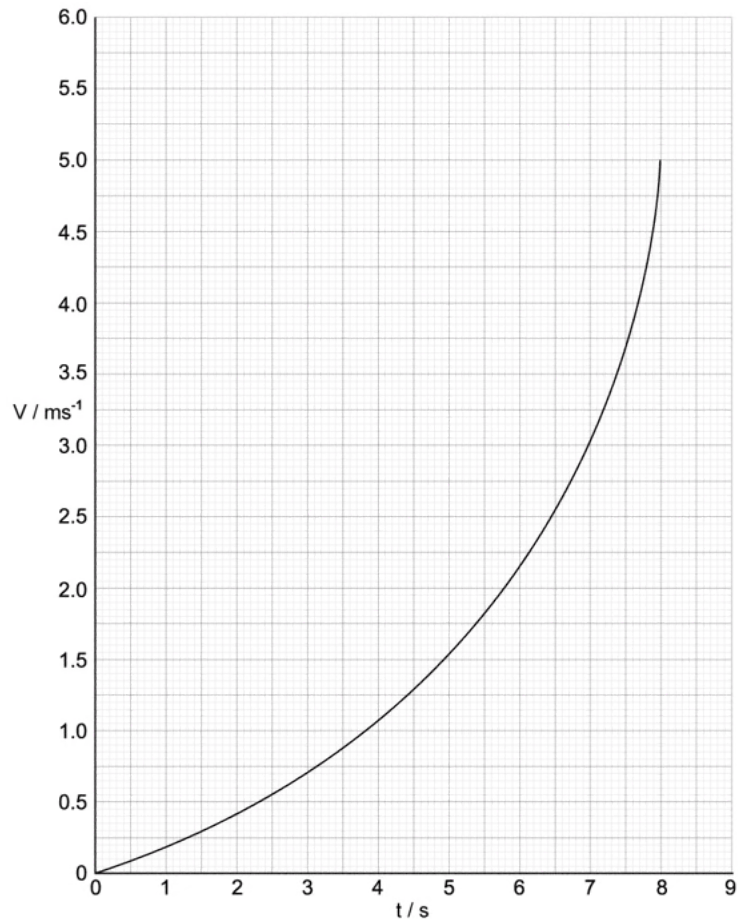
Sketch the graph to show how the displacement  $s$  of the stone changes with time  $t$  from when it is thrown in the air to when it touches the surface of the sea.



[3 marks]

### Question 3a

The graph shows how the velocity  $v$  of a particle varies with time  $t$ .



At time  $t = 0$  the instantaneous velocity of the particle is 0.

(a)

Calculate the instantaneous acceleration of the particle at time  $t = 6$  s.

[3 marks]

### Question 3b

The velocity of the particle, as shown on the graph on part (a), is its vertical velocity. At  $t = 5$  s, its horizontal velocity is  $2.5 \text{ m s}^{-1}$ .

(b)

Calculate the angle of the particle from the horizontal at  $t = 5$  s.

**[3 marks]**

### Question 3c

A different particle falls under gravity for  $0.7$  m from rest. Assume that air resistance is negligible.

(c)

Calculate:

- (i) The final velocity of the particle.
- (ii) The time when it first reaches this velocity.

**[4 marks]**

### Question 3d

A third particle now falls under the effect of both gravity and air resistance.

After falling for some time, its resultant force becomes zero for the rest of its motion. It reaches the same final velocity in the same time as the second particle, where air resistance was not present.

(d)

Sketch the motion of this third particle on the graph in part (a).

[2 marks]

### Question 4a

(a)

Describe how the fluid resistance on an object in free fall means it reaches a terminal velocity.

[5 marks]

### Question 4b

A bird drops a spherical graphite rock of density  $2230 \text{ kg m}^{-3}$  and radius 3 cm vertically down a water well. After it hits the water surface, it rapidly reaches a terminal speed as it falls through the well.

(b)

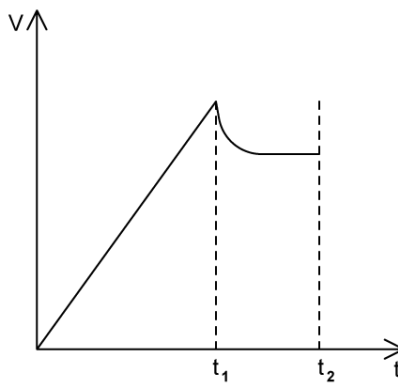
Calculate the magnitude of the fluid resistance from the water on the rock whilst it travels at terminal speed.

[4 marks]



**Question 4c**

The bird drops the rock 14 m above the water's surface.  $t_1$  is the time when the rock hits the water surface and  $t_2$  is when the rock is at rest at the bottom of the well, which is 70 m deep.



(c)  
Determine the value of  $t_1$ .

[2 marks]

**Question 4d**

(d)  
Calculate the speed at which the rock hits the water.

[3 marks]

**Question 5a**

Two identical balls are dropped from rest from the same height. One of the balls is dropped 1.50 s after the other.

(a)

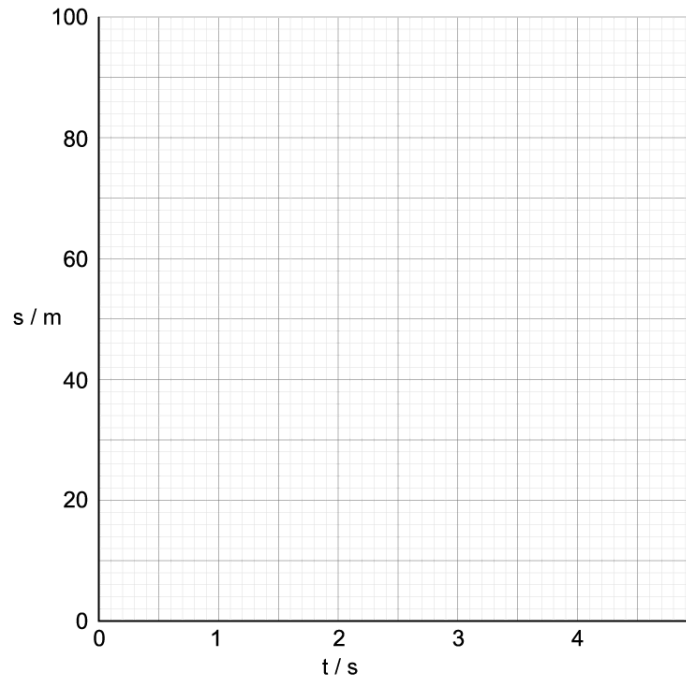
Calculate the distance that separates the two balls 3.00 s after the second ball is dropped.

**[4 marks]**

### Question 5b

(b)

Draw the displacement-time graphs for both balls.



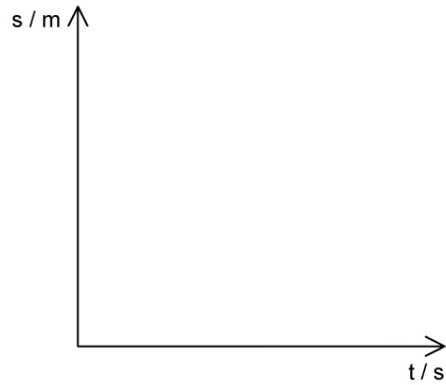
[3 marks]

### Question 5c

One of the balls is now dropped from the same height again from rest. After 2 seconds, it enters a cylinder of oil where it then no longer accelerates.

(c)

Sketch on the displacement–time graph the motion of this ball.



[3 marks]

### Question 5d

A different ball, that is identical in every way but is much heavier than the first two is now dropped from a certain height. Again, after 2 seconds, it enters a cylinder of oil where it then no longer accelerates.

(d)

Compare and contrast how the displacement–time graph from part (c) would change for this heavier ball. Assume that air resistance is negligible.

[4 marks]

