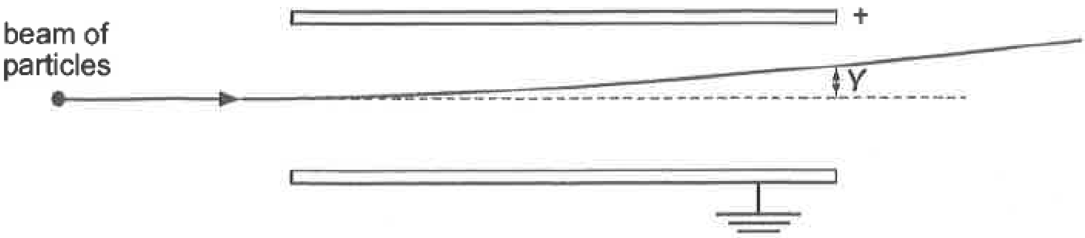
2023 Sec 3 Advanced Physics AS 1

Kinematics: Non-linear Motion ANSWERS

Name: ____________________ ( ) Class: 3 / ___

1 Two horizontal metal plates are situated in a vacuum. A potential difference is maintained between the plates.



A beam of negatively-charged particles is horizontal when it enters the region between the plates. It is deflected as shown in the diagram.

The potential difference is then increased. How does this affect the time *T* that a particle in the beam spends between the plates and the vertical deflection *Y*?

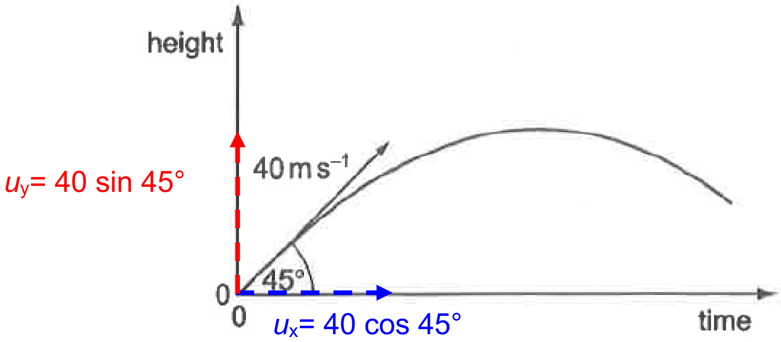
	effect on *T*	effect on *Y*
A	decreases	decreases
B	no change	increases
C	no change	decreases
D	increases	increases

Answer: B

The electrical potential difference affects the force on the particles and their acceleration in the vertical direction.

The time T is determined by the horizontal velocity which remains constant.
The vertical deflection Y increases as the vertical acceleration increases, due to increase in potential difference.

2 An object is projected with velocity 40 ms^{-1} at an angle of 45° to the horizontal. Air resistance is negligible.



What is the speed of the object after 5.0 s?

A 21 m s^{-1} **B** 28 m s^{-1} **C** 35 m s^{-1} **D** 49 m s^{-1}

Horizontal motion: $v_x = u_x$= 40 cos 45°
Vertical motion:
Sign convention: upwards is positive

$v_y = u_y + a_y t$
= 40 sin 45° + (-10) (5.0)
= -21.716 m s^{-1}

$$v = \sqrt{v_x^2 + v_y^2}$$
$$= \sqrt{(40\cos 45°)^2 + (-21.716)^2}$$
= 35.7 m s^{-1}

Note to student: The value of g is taken to be 9.81 m s^{-2} for the A levels syllabus. The answer for option (C) is based on g = 9.81 m s^{-2}.

(**C**)

3 A student throws a ball from a point S to a friend at point F. The path of the ball is shown in Fig. 3.1.

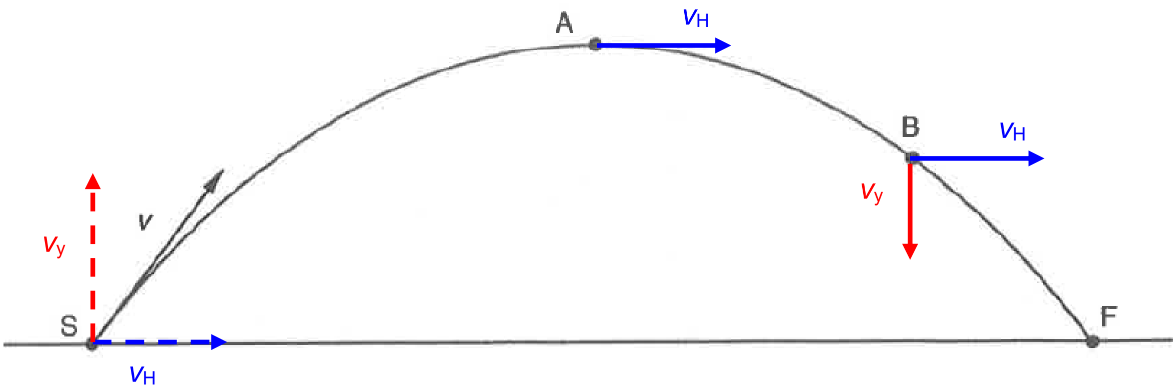


Fig. 3.1

The points S and F are on the same horizontal level. Air resistance is negligible. The ball is thrown from point S with velocity v, represented by the vector arrow shown on Fig. 3.1

(a) On Fig. 3.1,

(i) draw arrows from **S** to represent the initial horizontal and vertical components of the velocity *v*, and label these components $\boldsymbol{v_H}$ and $\boldsymbol{v_v}$ respectively,

(ii) draw and label arrows at **A** and at **B** to represent the horizontal and vertical components of the velocity of the ball at these two points.

(b) The initial velocity of the ball at S is 25 m s^{-1} at an angle of 45° to the horizontal.

(i) Calculate the vertical component of the ball's initial velocity.

u_y= u sin θ = 25 sin 45°
= 17.678
= 18 m s^{-1} (2 s.f.)

vertical component of velocity = ……18 m s^{-1} upwards………..

(ii) Determine the **maximum height** reached by the ball, assuming no air resistance.

At maximum height, v_y = 0
Vertical motion:
Sign convention: upwards is positive

$$v_y^2 = u_y^2 + 2a_y s_y$$

$0^2 = (25\sin 45°)^2 + 2\,(-10)\,s_y$
s_y = 15.625 = 16 m (2 s.f.)

maximum height = ……………………………..

(iii) Determine the horizontal distance SF.

Vertical motion:
Sign convention: upwards is positive

$$s_y = u_y t + \frac{1}{2} a_y t^2$$

$0 = (25\sin 45°)\,t + ½\,(-10)\,t^2$
t = 0 s (initial position) or t = 3.5355 s

horizontal motion:

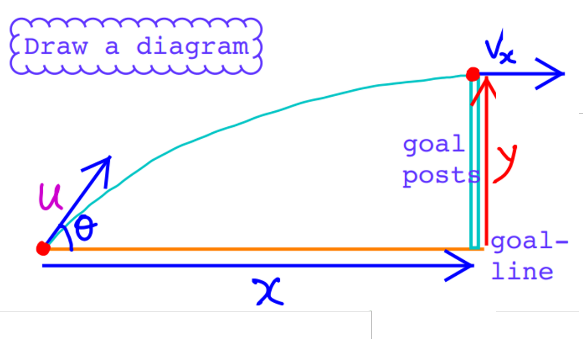
$s_x = u_x t$
$= (25 \cos 45°)(3.5355)$
$= 62.499$ m
$= 62$ m (2 s.f.)

distance = ……………………………..

$v_y = 0$

4 A ball is to be kicked so that, at the **highest point** of its path, it **just clears a horizontal cross-bar** on a pair of goal-posts. The ground is level and the cross-bar is 2.5 m high. The ball is kicked from ground level with an initial speed of 8.0 m s^{-1}.

(a) Calculate the angle of projection of the ball.



Consider vertical motion
Sign convention: upwards is positive

$v_y^2 = u_y^2 + 2a_y s_y$
$0^2 = (u \sin \theta)^2 + 2(-10)(2.5)$
$(8.0 \sin \theta)^2 = 2(10)(2.5)$
$\sin \theta = \frac{\sqrt{50}}{8.0}$
$\theta = 62.114° = 62°$ (2 s.f.)

angle of projection = ……………………………..

(b) Calculate the horizontal velocity of the ball as it passes over the cross-bar.

$v_x = u_x = u \cos \theta$
$= 8.0 \cos 62.114°$
$= 3.7417$
$= 3.7$ m s^{-1} (2 s.f.)

horizontal velocity = ……………………………..

(c) Calculate the distance of the point where the ball is kicked from the goal-line.

Consider vertical motion
Sign convention: upwards is positive
$v_y = u_y + a_y t$
$0 = 8.0 \sin 62.114° + (-10) t$
$t = 0.70711$ s

horizontal motion:
$s_x = u_x t$
$= (3.7417)(0.70711)$
$= 2.6458$
$= 2.6$ m (2 s.f.)

distance from goal-line = ……………………………..

(d) Determine the time the ball is in the air before it **reaches the ground** on the other side of the cross-bar.

total time = 2x *t*
= 2 x 0.70711
= 1.4142
= 1.4 (2 s.f.)

time = ……………………………..

5 **(a)** At launch (t=0 s) u_Y = 150sin27° = 68.099 m/s

u_X = 150cos27° = 133.65 m/s [1]

Considering vertical components,

u_Y = 68.099 m/s, a = -10 m/s^2, s_Y = -300 m, t = ?

$s_Y = u_Y t + \frac{1}{2}at^2$

$-300 = 68.099t + \frac{1}{2}(-10)t^2$

t = 17.1 s [1] (OR t = -3.50 -ignore)

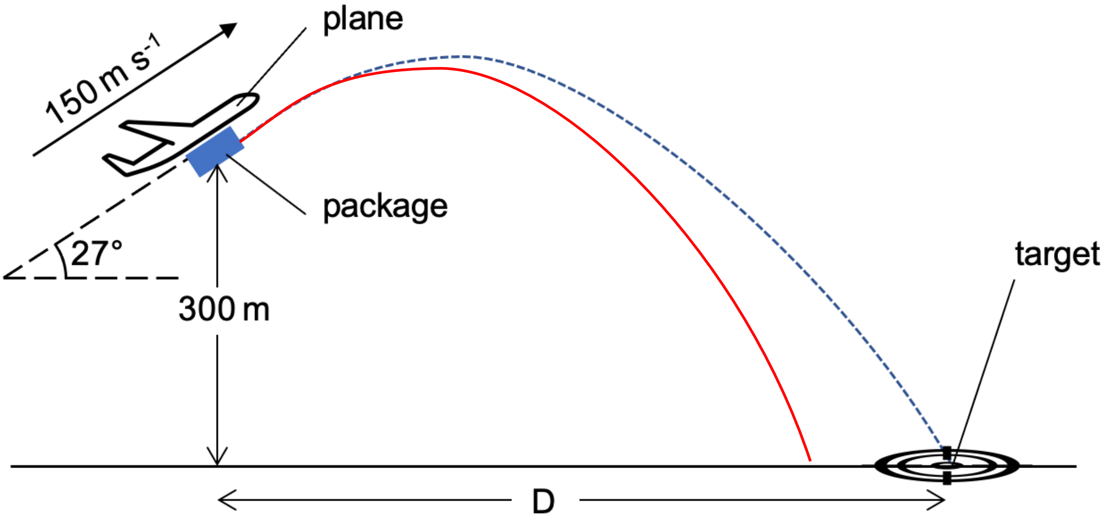
Horizontal distance travelled in 17.1 s,

$s_X = u_X t$

= 133.65 x 17.1

= 2.29 km [1]

(b)



New path to have max height lower, and nearer to plane & final impact point closer to the plane. [1]

Answers:	1. B 2. C 3(aii) v_H is constant at all points, v_v is zero at A & downwards at B 4(a) 62° (b) 3.7 m s^{-1} (c) 2.6 m, (d) 1.4 s