KINEMATICS

Challenging **MCQ** questions by The Physics Cafe

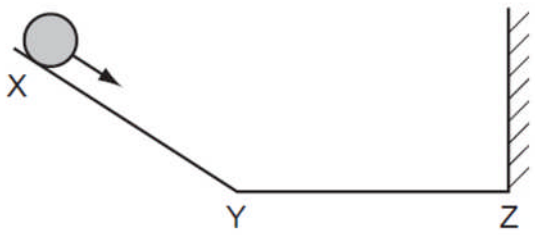
Compiled and selected by The Physics Cafe

1 Two diamonds begin free fall from rest from the same height 1.0 s apart.

How long after the first diamond begin to fall will the two diamonds be 10 m apart?

A 0.43 s **B** 1.43 s **C** 1.52 s **D** 2.43 s

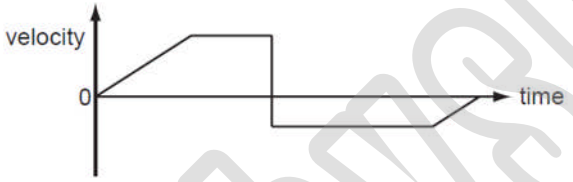
2 A ball is released from rest on a smooth slope XY.



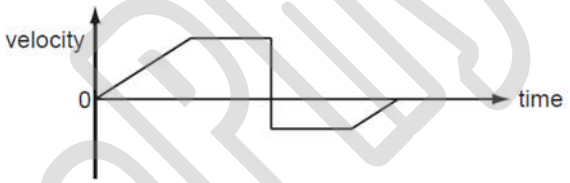
It moves down the slope, along a smooth surface YZ and rebounds inelastically at Z. Then it moves back to Y and comes to rest momentarily somewhere on XY.

Which velocity-time graph represents the motion of the ball?

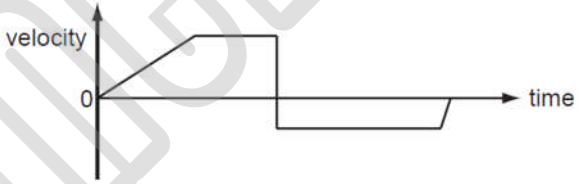
A.



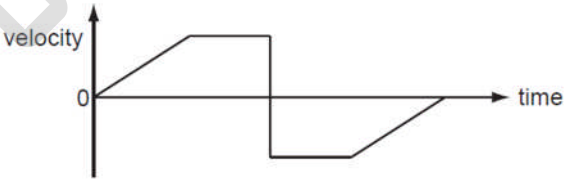
B.



C.



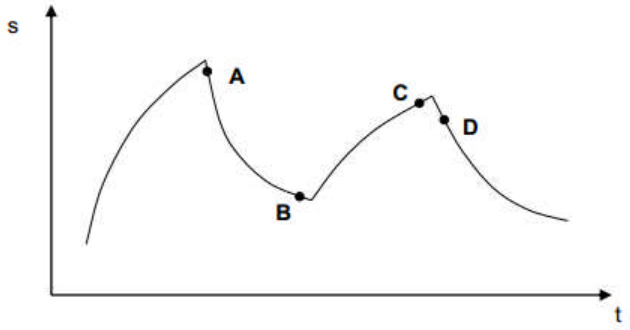
D.



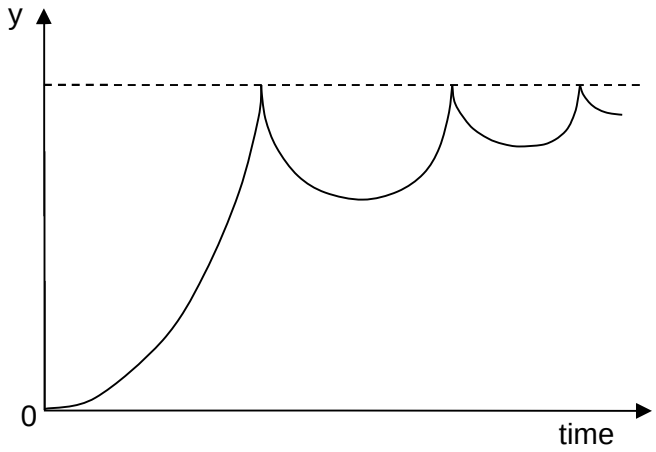
3 A golf ball travels with an initial speed v_o and it went only one-third of the way to the hole. Assuming the force of resistance due to the grass remains the same, what new initial speed should the ball travel for the ball to go into the hole?

A $\sqrt{2}v_o$ **B** $\sqrt{3}v_o$ **C** $\sqrt{6}v_o$ **D** $3v_o$

4 The graph is a displacement-time (*s*-*t*) graph for a tennis ball during part of a game. Which part of the graph shows the highest speed?



5 The graph below describes the motion of an object rebounding from a horizontal surface after being released from a point above the surface.



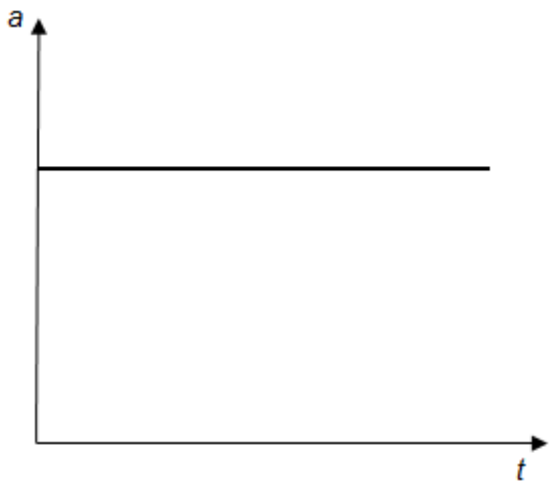
The quantity represented on the y-axis is the ball's

A acceleration **B** displacement **C** Momentum **D** velocity

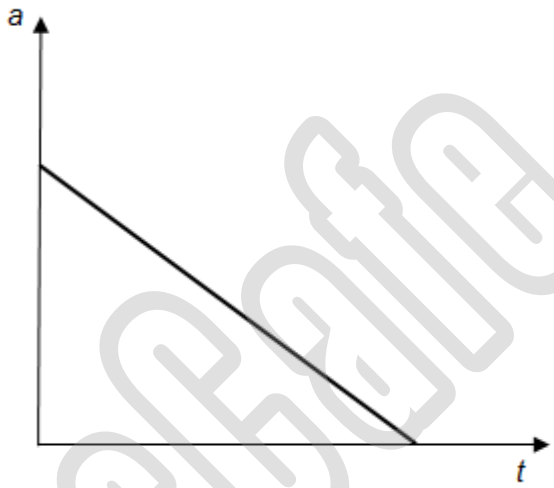
6 A metal sphere is held just below the surface of a deep tank of liquid and released.

Which of the following best illustrates how the acceleration *a* varies with time *t* after release?

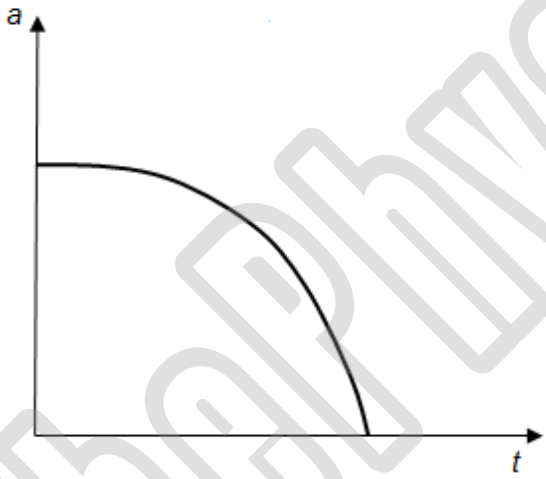
A



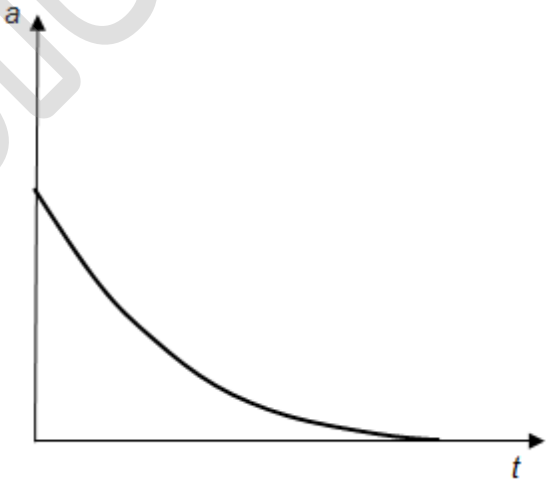
B



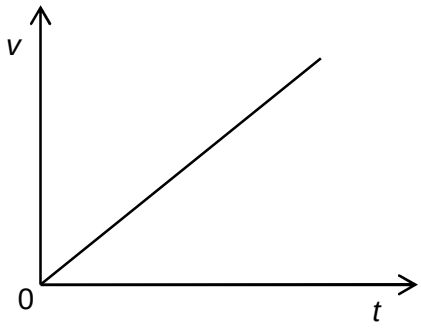
C



D

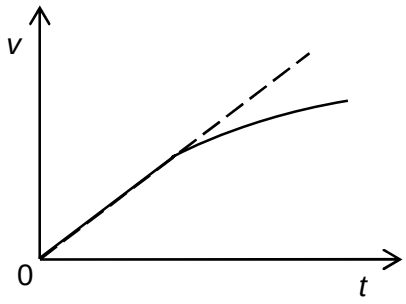


7 A body falls from rest in a vacuum near the Earth's surface. The variation with time *t* of its speed *v* is shown below.

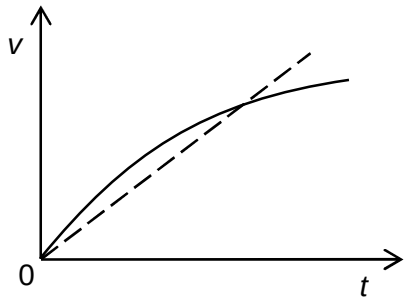


Which graph shows the variation with time *t* of the speed *v* of the same ball falling in air at the same place on Earth?

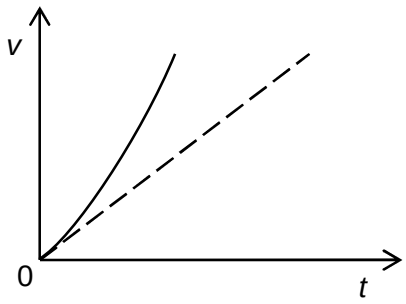
A



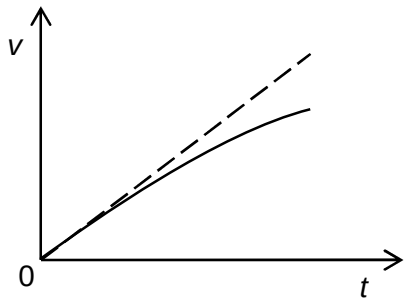
B



C



D



8 A force *F* is applied to a freely moving object. At one instant of time, the object has velocity *v* and acceleration *a*.

Which quantities must be in the same direction?

A *a* and *v* only
B *a* and *F* only
C *v* and *F* only
D *v*, *F* and *a*

9 A fighter bomber is travelling at 70 m s^{-1} horizontally at a height of 500 m above sea level. It is on a bombing run to its target, a naval ship which is moving at 20 m s^{-1} towards the bomber.

Assume negligible air resistance.

If the pilot wants to score a direct hit, he should release the bomb

A when the plane is 260 m away from the naval ship horizontally.
B when the plane is 470 m away from the naval ship horizontally.
C when the plane is 710 m away from the naval ship horizontally.
D when the plane is 910 m away from the naval ship horizontally.

(YJC, 2014)

10 A raindrop, in still air, falls at a constant vertical terminal velocity of 1.8 m s^{-1}. If the raindrop were to fall through air in which a horizontal wind of velocity 1.4 m s^{-1} is blowing, calculate the magnitude of the resultant velocity of the raindrop.

A 0.4 m s^{-1} **B** 1.8 m s^{-1} **C** 2.3 m s^{-1} **D** 3.2 m s^{-1}

11 Two stones, X and Y, of different mass are dropped from the top of a cliff. Stone Y is dropped a short time after stone X. Air resistance is negligible. Whilst the stones are falling, the distance between them will

A Decrease if the mass of Y is more than the mass of X

B Increase if the mass of X is more than the mass of Y

C Decrease regardless if the mass of X more than or less than the mass of Y.

D Increase regardless if the mass of X is more than or less than the mass of Y

12 A bullet is aimed directly and horizontally at the centre of a target which is 100 m away. If the bullet is then fired at a speed of 200 m s^{-1}, what is the distance the bullet will land from the centre of the target?

A 0 cm **B** 12 cm **C** 123 cm **D** 196 cm

13 A man of mass *M* is standing on a weighing scale in an elevator. The elevator undergoes several different motions as described below.

Elevator's motion	**Weighing scale reading**
Moving downwards and coming to rest with uniform deceleration	N_1
Moving downwards and speeding up with constant acceleration	N_2
Moving downwards with constant speed	N_3

Which of the following is correct?

A $N_1 = N_2 = N_3$

B $N_1 = N_2 < N_3$

C $N_1 < N_3 < N_2$

D $N_2 < N_3 < N_1$

14 A ball, when thrown vertically upward in an evacuated tube on Earth with an initial speed of *u*, returns to the point of throw with a speed of *u* after time *t*.

The same ball is thrown vertically upward in air on Earth with the same initial speed *u*.

Which of the following correctly describes the speed of this ball when it returns to the point of throw and the time taken to do so?

	speed of ball	time taken
A	less than *u*	less than *t*
B	less than *u*	more than *t*
C	more than *u*	less than *t*
D	more than *u*	more than *t*

15 A projectile is launched at an angle of 30° to the horizontal. Its initial kinetic energy is *E*.

If air resistance is negligible, what is the projectile's kinetic energy at the highest point of motion?

A zero **B** 0.50 **C** 0.75 *E* **D** *E*

KINEMATICS WORKED SOLUTIONS

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1 Ans: **C**

Solving $\frac{1}{2}gt^2 - \frac{1}{2}g(t-1)^2 = 10$ gives t = 1.52 s

2 Ans: **A**

The 2 slopes have the same gradient since same magnitude of acceleration.
The time taken to travel back to slope is longer after collision since speed after rebound is lower.

3 Ans: **B**

$0 = v_o^2 - 2a(\frac{1}{3}s) \Rightarrow v_o^2 = 2a(\frac{1}{3}s)$ ---------- (1) OR using $\frac{1}{2}mv^2 = Fx$

$0 = u^2 - 2as \Rightarrow u^2 = 2as$ ----------(2)

(1)/(2) : $\frac{v_o^2}{u^2} = \frac{1}{3}$

$u = \sqrt{3}v_o$

4 Ans: **A**

A has the steepest gradient.

5 Ans: **B**

The point of release is taken to be y = 0 and the displacement from the horizontal surface from which the ball rebounds from is represented by the dotted line on the graph. The displacement of the ball is observed to decrease with time for subsequent bounces due to loss of energy.

6 Ans: **D**

Assuming that drag is proportional to v
Net force acting on sphere is $F_{net} = mg - kv$

$ma = mg - kv$

$-kv = ma - mg$

Differentiating the above equation with respect to time t,

$-k\frac{dv}{dt} = m\frac{da}{dt}$ [$\frac{dv}{dt} = a$]

$-ka = m\frac{da}{dt}$

$\frac{da}{dt} = -\frac{ka}{m}$

At time t = 0, sphere is just released from rest and v = 0, $a = g$.
a = 0, is when sphere reaches terminal velocity (where v is a maximum constant value).
Note that $\frac{da}{dt}$ represents the gradient of the a-t graph. The negative sign indicates that the graph is downward sloping. The value of gradient $\frac{da}{dt}$ decreases with time since a decreases from g to 0. Hence a-t graph is a curve whose gradient is negative and decreases with time.

7 Ans: **D**

8 Ans: **B**

9 Ans: **D**

10 Ans: **C**

11 Ans: **D**

12 Ans: **C**

13 Ans: **D**

14 Ans: **A**

With air resistance, the deceleration while the ball rises up becomes larger, resulting in a lower height reached. When it falls, it falls with a smaller acceleration (over a shorter distance), resulting in a smaller speed when returning to the point of throw. Alternatively, applying the Principle of Conservation of Energy also points to the conclusion that the KE of the ball when returning will be smaller than initial because work is done against air resistance.

Because of the larger deceleration when the ball rises, it reaches a lower height in a shorter time. The overall time of flight hence becomes smaller than when without air resistance.

15 Ans: **C**

The initial horizontal speed of the projectile is $u\cos30° = 0.866u$

Its initial kinetic energy E is equal to $\frac{1}{2} mu^2$

At the highest point of its flight, the speed of the projectile is equal to $0.866u$ and it moves completely horizontally. This is because the vertical speed is zero at this point, leaving only the constant horizontal speed of $0.866u$.

The kinetic energy at this highest point = $\frac{1}{2} m(0.866u)^2 = 0.75 (\frac{1}{2} mu^2) = 0.75 E$