Worked Solutions for ENGAA Papers by Topic

Section 2

Topic: Kinematics

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ENGAA S2 2020 - Question 5

5 A projectile is fired upwards from the ground at an angle of 60° to the vertical at a speed of $20\,\text{m s}^{-1}$.

It travels a horizontal distance d and lands with a downwards vertical component of velocity of $4.0\,\text{m s}^{-1}$ on ground that is height h above the starting point of the projectile.

What are d and h?

(gravitational field strength = $10\,\text{N kg}^{-1}$; assume that air resistance is negligible)

	d / m	h / m
A	$6.0\sqrt{3}$	4.2
B	$6.0\sqrt{3}$	5.8
C	$10\sqrt{3} - 4.0$	4.2
D	$10\sqrt{3} - 4.0$	14.2
E	$10\sqrt{3} + 4.0$	5.8
F	$10\sqrt{3} + 4.0$	14.2
G	$14\sqrt{3}$	4.2
H	$14\sqrt{3}$	5.8

ENGAA S2 2020 - Question 5 - Worked Solution

Consider vertical component

$$v^2 - u^2 = 2as$$

$$(-4)^2 - (20\sin 30)^2 = 2(-10)h$$

$$h = 4.2\text{m}$$

To find d we need vertical flight time

$$v = u + at$$

$$-4 = 20\sin 30 - 10t$$

$$t = 1.4\text{s}$$

Horizontally:

$$d = v \cdot t = 20\cos 30 \times 1.4$$

$$d = 14\sqrt{3}$$

Answer is G

ENGAA S2 2020 - Question 10

10 A cyclist travels at a constant speed of $12\,\text{m}\,\text{s}^{-1}$ on level ground. During this time the power needed to maintain a constant speed is 900 W. The total weight of the cyclist and bicycle is 850 N.

The cyclist now cycles up a slope at the same constant speed. The slope is at an angle of 30° to the horizontal.

What is the driving force on the bicycle as it travels up the slope?

(Assume that the magnitude of the resistive forces is constant.)

A 75 N

B 350 N

C 500 N

D $(425\sqrt{3} - 75)\text{N}$

E 775 N

F $(425\sqrt{3} + 75)\text{N}$

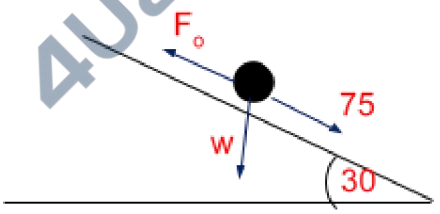
G 925 N

ENGAA S2 2020 - Question 10 - Worked Solution

$$d = s\,.\,t = 12\text{cm}$$

$$W = F\,.\,d$$

$$F = 75\text{N}$$



Weight down slope : $W \sin\sin 30$

thus for balanced forces on slope:

$$F_o - 75 - 850 \sin\sin 30 = 0$$

$$F_o = 500\text{N}$$

Answer is C

ENGAA S2 2020 - Question 15

15 A trolley of mass 3.0 kg is moving horizontally along a smooth track. Its displacement x from a point at time t is given by the equation:

$$x = 8 + 4t + 2t^2$$

where x is in metres and t is in seconds.

How much work is done on the trolley between times $t = 0$ and $t = 5.0$ s?

A 12 J

B 24 J

C 78 J

D 270 J

E 840 J

F 864 J

G 936 J

ENGAA S2 2020 - Question 15 - Worked Solution

$$V = \frac{dx}{dt} = 4 + 4t$$

$$V(t = 0) = 4$$

$$V(t = 5) = 24$$

$$W = \Delta T = \frac{1}{2}m\left(24^2 - 4^2\right)$$

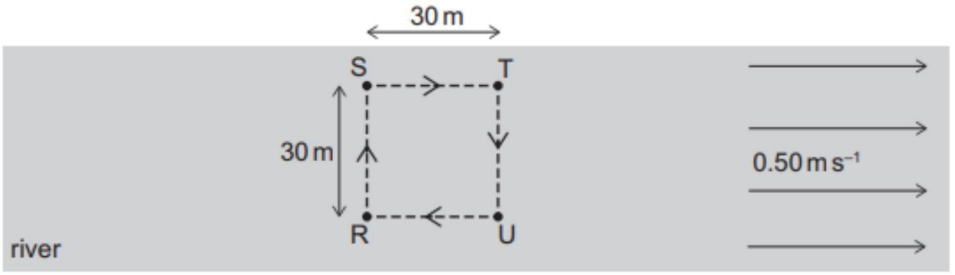
$$W = 840J$$

Answer is E

ENGAA S2 2020 - Question 17

17 Water in a wide river flows at a constant speed of $0.50\,\text{m s}^{-1}$. A swimmer swims around a square path of side 30 m marked out by 4 posts R, S, T and U which are fixed to the river bed, as shown.

The swimmer has a constant speed of $1.0\,\text{m s}^{-1}$ relative to the water.



How long does it take for the swimmer to swim around the square path once?

A $(60 + 24\sqrt{5})\,\text{s}$

B $(60 + 40\sqrt{3})\,\text{s}$

C $(80 + 24\sqrt{5})\,\text{s}$

D $(80 + 40\sqrt{3})\,\text{s}$

E 120 s

F 140 s

ENGAA S2 2020 - Question 17 - Worked Solution

$$\text{S T} : 1\text{ms}^{-1}$$

$$\text{TU} : 0.5 - 1$$

$$\text{UR} : -0.5$$

$$\text{RS} : 0.5 + 1$$

$$For\ vertical\quad v = \sqrt{1^2 - 0.5^2}$$

$$= \frac{\sqrt{3}}{2}\text{ms}^{-1}$$

$$vert : 2 \times \frac{30m}{\sqrt{3}/2} = 40\sqrt{3}\ s$$

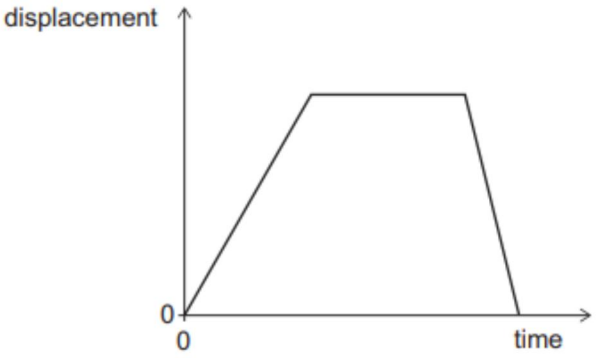
$$hoz : \text{t} = \frac{30}{1.5} + \frac{30}{0.5} = 80\ \text{s}$$

$$: \text{d} = 80 + 40\sqrt{3}$$

Answer is D

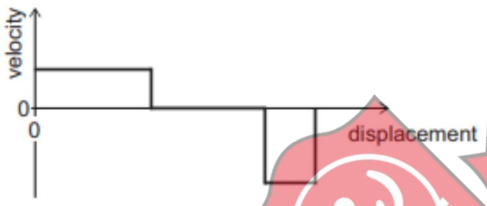
ENGAA S2 2020 - Question 19

19 The following graph shows how the displacement of an object travelling along a straight, horizontal track varies with time.

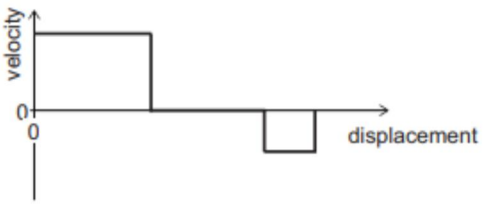


Which graph shows the velocity of this object against displacement?

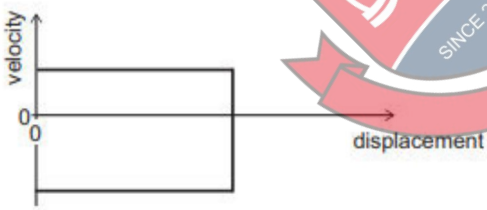
A



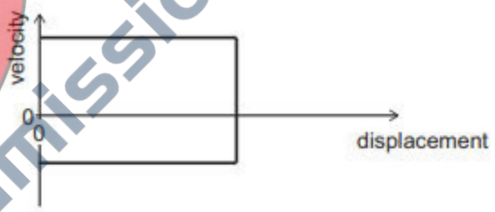
B



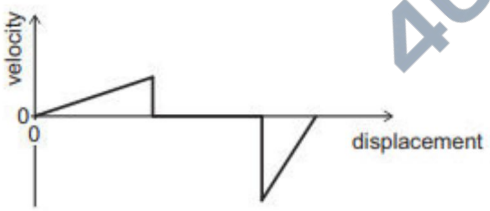
C



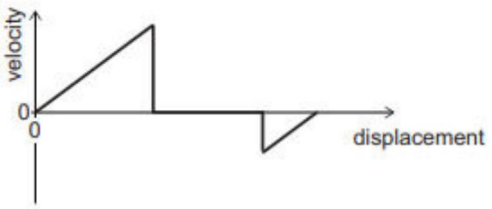
D



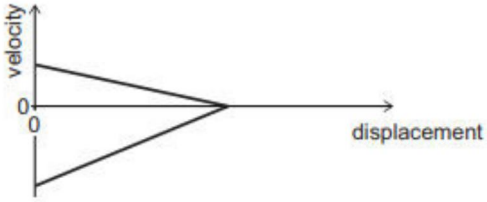
E



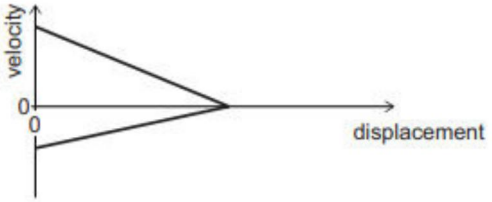
F



G



H



ENGAA S2 2020 - Question 19 - Worked Solution

Answer is C

ENGAA S2 2019 - Question 9

9 A block of mass 2.0 kg slides directly down a smooth slope.

The slope is at an angle of 30° to the horizontal.

The block reaches a speed of 8.0 m s^{-1}, at which point the slope becomes rough and the block begins to decelerate.

After travelling a distance of 4.0 m down the rough slope the block comes to rest.

What is the magnitude of the average friction force between the block and the rough slope?

(gravitational field strength = 10 N kg^{-1}; assume that air resistance is negligible)

A 2.0 N

B 6.0 N

C 10 N

D 12 N

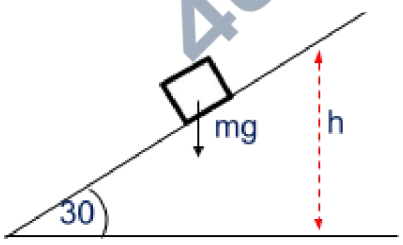
E 16 N

F $10\sqrt{3}$ N

G 26 N

H $(16 + 10\sqrt{3})$ N

ENGAA S2 2019 - Question 9 - Worked Solution



$h = 4\text{m} \cdot \sin \text{Sin } 30o$

$\frac{1}{2}mu^2 + mgh = \frac{1}{v}mv^2 + mgh' + F \cdot S$

Initial E = Final E + work done by friction

$\frac{1}{2}(2)8^2 + 2\times10\times4\sin sin\,30 = \frac{1}{2}(2)0^7 + 2\times10\times0 + F.4$

$F = \frac{104}{4} = 26$

Answer is G

ENGAA S2 2019 - Question 11

11 A car is travelling along a straight road with constant acceleration. It passes a road sign.

It travels 12.2 m in the 3rd second and 14.4 m in the 4th second after passing the road sign.

What was the speed of the car as it passed the road sign?

A $2.20\,ms^{-1}$

B $4.50\,ms^{-1}$

C $6.70\,ms^{-1}$

D $7.80\,ms^{-1}$

E $13.3\,ms^{-1}$

F $37.2\,ms^{-1}$

ENGAA S2 2019 - Question 11 - Worked Solution

$$S = u + \frac{1}{2}at^2$$

$$12.2m = V_2 . 1() + -\frac{1}{2} a\ 1()^2$$

$$12.2 + 14.4 = V_2\ 2() + -\frac{1}{2} a\ a()^2$$

$$24.4 = 2V_2 + a$$

$$26.6 = 2V_2 + 2a$$

$$a = 2.2ms^{-2}$$

$$V_2 = 11.1ms^{-1}$$

$$V_0 = V_2 - at$$

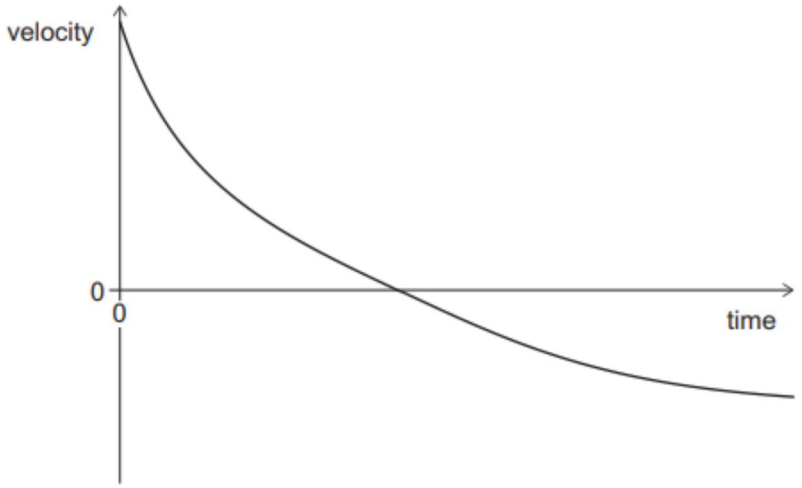
$$= 11.1 - 2.2\times2$$

$$V_0 = 6.7ms^{-1}$$

Answer is C

ENGAA S2 2019 - Question 16

16 A ball is thrown vertically upwards in air. The ball travels upwards to reach its highest point and then falls back down to its initial starting position. The velocity–time graph for the ball is shown.



Which of the following statements is/are correct?

1. The magnitude of the acceleration of the ball is only equal to the magnitude of the acceleration of free fall when it is at its highest point.
2. The time taken for the upward journey of the ball is equal to the time taken for the journey back down to its starting position.
3. The maximum increase in the gravitational potential energy of the ball is less than its initial kinetic energy and greater than its kinetic energy when it returns to its starting position.

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

ENGAA S2 2019 - Question 16 - Worked Solution

2 & 3 are based on reasoning of air resistance messing with the system's conservation.

Answer is F

ENGAA S2 2019 - Question 17

17 A stone is projected from level ground at an angle of 30° to the horizontal.

After 1.0 s the stone lands on a ledge at height h above the level ground.

During this journey the vertical component of velocity of the stone is upwards for the first 0.60 s and downwards for the remaining 0.40 s.

What is the value of h?

(gravitational field strength = 10 N kg^{-1}; assume that air resistance is negligible)

A 1.0 m

B 1.6 m

C 2.0 m

D 3.0 m

E 3.2 m

F 6.0 m

G 7.0 m

H 11 m

ENGAA S2 2019 - Question 17 - Worked Solution

$$\text{At top, } v_y = 0$$

$$v_y = u_y - gt$$

$$v_y = v_0 \sin\sin 30 - 10\times 0.6s$$

$$\therefore v_0 = 12ms$$

$$S = ut + \frac{1}{2}at^2$$

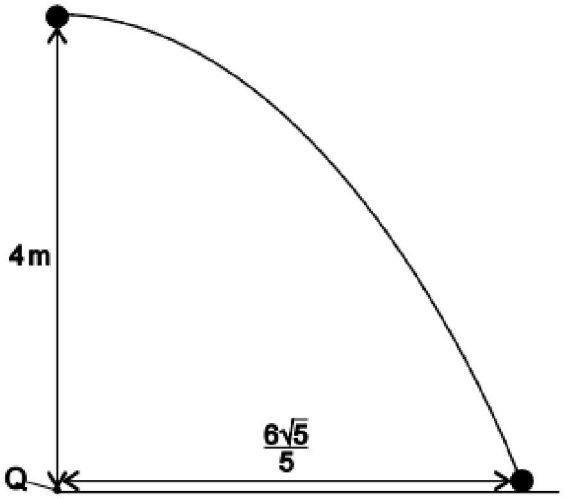
$$h = 12 \sin\sin 30 \,.\, (1.0s) - \frac{1}{2}(10)(1.0)^2$$

$$h = 1m$$

Answer is A

ENGAA Specimen S2 - Question 5

5 A ball is thrown horizontally with velocity v from a height of 4 m vertically above a point Q that is on horizontal ground.



The ball hits the ground at a distance of $\frac{6\sqrt{5}}{5}$ m from Q.

What is the value of v?

(gravitational field strength = 10 N kg^{-1}; air resistance is negligible)

A $\frac{3}{5}$ m s^{-1}

B $\frac{3}{\sqrt{5}}$ m s^{-1}

C 3 m s^{-1}

D $3\sqrt{2}$ m s^{-1}

E $3\sqrt{5}$ m s^{-1}

ENGAA Specimen S2 - Question 5 - Worked Solution

Use suvats

vertically $S = 4m$, $u = 0mS^{-1}$, $a = 10mS^{-2}$

$S = ut + \frac{1}{2}at^2$

$4 = 5t^2$

$t^2 = \frac{4}{5}$

$t = \frac{2}{\sqrt{2}}$

Horizontally v => constant

$S = vt$

$\frac{6\sqrt{5}}{5} = v \times \frac{2}{\sqrt{5}}$

$v = 3mS^{-1}$

Answer is C

ENGAA Specimen S2 - Question 16

16 Two point masses, P and Q, are 60m apart at time $t = 0$.

P has a constant acceleration of $6.0\,ms^{-2}$ in the direction towards Q. At time $t = 0$, P has a velocity of zero.

Q has a constant acceleration of $2.0\,ms^{-2}$ in the direction away from P. At time $t = 0$, Q has a velocity of $14\,ms^{-1}$ towards P.

At what time do the masses meet?

A 2.5s

B 3.0s

C 3.5s

D 6.0s

E 6.5s

F 7.0s

G 10s

ENGAA Specimen S2 - Question 16 - Worked Solution

position of p use suvats

$s = ?\ ,\ u = 0\ ,\ v\ ,\ a = 6.0\ ,\ t = t$

$$s = ut + \frac{1}{2}at^2$$

$$= 3t^2$$

Position of Q

$$s = 60 - 14t + \frac{1}{2} \times 2 \times t^2$$

$$= 60 - 14t + t^2$$

$$S_p = S_Q : \quad 60 - 14t + t^2 = 3t^2$$

$$2t^2 + 14t - 60 = 0$$

$$t^2 + 7t - 30 = 0$$

$$(t + 10)(t - 3) = 0$$

$$t = -10\ ,\ t = 3$$

T must be +ve

they meet at $t = 3s$

Answer is B

ENGAA S2 2018 - Question 1

1 A man is cycling along a straight horizontal road at a constant speed of $9.00\,m\,s^{-1}$.

He passes a boy who is cycling at $5.00\,m\,s^{-1}$ in the same direction.

When the man is level with the boy, the boy begins to accelerate at a constant rate of $0.800\,m\,s^{-2}$.

The boy maintains this constant acceleration and the man continues at constant speed until the boy passes the man.

What is the time interval between the two instances when the man and the boy are level?

A 5.00 s

B 10.0 s

C 22.5 s

D 35.0 s

E 90.0 s

ENGAA S2 2018 - Question 1 - Worked Solution

S_M = distance travelled by man

S_B = distance travelled by boy

Meet when $S_M = S_B$

At $t = 0$, B passes M initially

At $t = t$, B passes M again

$S_M = 9t$

Using SUVAT:

$$S_B = 5t + \frac{1}{2} \times 0.8t^2$$

$$= 5t + 0.4t^2$$

$S_M = S_B$

$$9t = 5t + 0.4t^2$$

$$0 = 4t(0.1t - 1)$$

$$t = 0 \text{ or } t = \frac{1}{0\,1} = 10$$

$t = 10$ when passes again

Answer is B.

ENGAA S2 2017 - Question 1

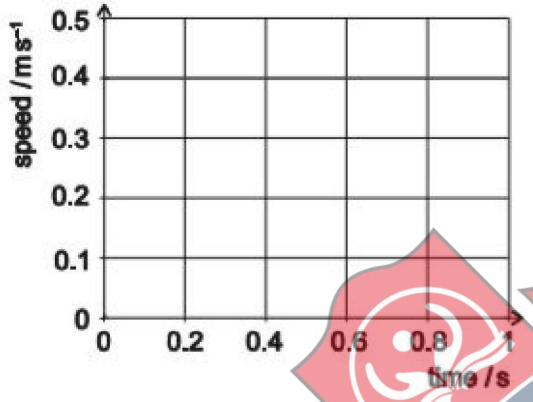
1 A ball of mass $m = 0.5\,\text{kg}$ is at rest a distance d above the flat floor of a spacecraft.

Installed in the floor is an artificial gravity generator which produces a field at right angles to the floor, directed towards the floor. There is no air in the spacecraft.

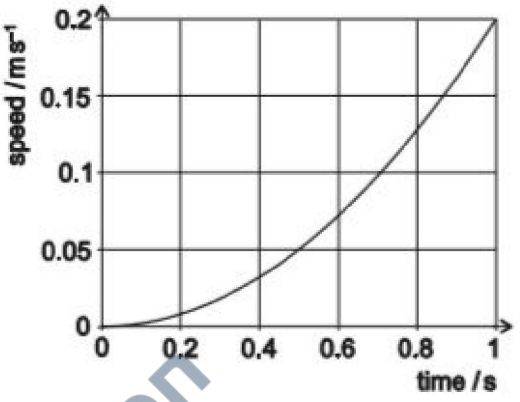
The generator is switched on at time $t = 0\,\text{s}$ and produces a field g that increases linearly with time, such that $g = 0.4t\ \text{m s}^{-2}$. The artificial gravity is the only force experienced by the ball.

a) Assuming that the ball does not hit the floor within the first second of motion, which of these graphs represents the speed of the ball plotted against time? **[2 marks]**

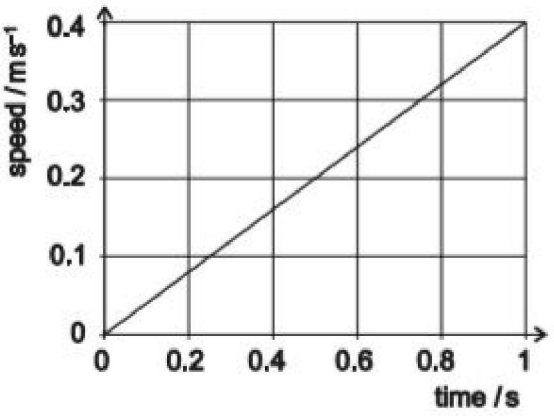
A



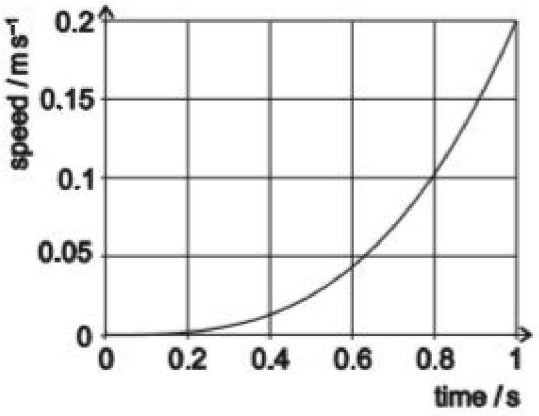
B



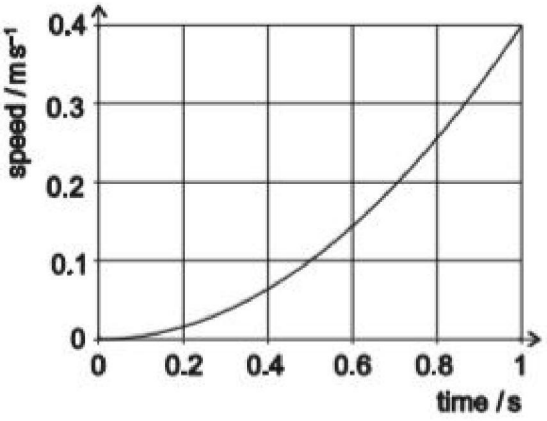
C



D



E



ENGAA S2 2017 - Question 1 - Worked Solution

a) Acceleration is not constant or 0, so not Graphs A or C

a = 0.4t

$\frac{dv}{dt} = 0.4t$

$v = \int_0^t 0.4t \, dt$

t = 0 , v = 0

$v = 0.2t^2$

So when t = 0.5 , v = 0.05 , so pick graph B

Answer is B

b)

b) Which of these expressions gives the time taken for the ball to first hit the floor? **[2 marks]**

A $(15d)^{\frac{1}{3}}$

B $(5d)^{\frac{1}{3}}$

C $(5d)^{\frac{1}{2}}$

D $\left(\frac{15d}{2}\right)^{\frac{1}{3}}$

E $\left(\frac{5d}{2}\right)^{\frac{1}{3}}$

T = time to hit floor

$v = \frac{ds}{dt}$ (s = displacement)

total displacement = d = $\int$ v dt

$$= d = \int_0^T 0.2t^2\, dt$$

$$= d = \frac{T^3}{15}$$

$T = (15d)^{1/3}$

Answer is A

c)

A P only

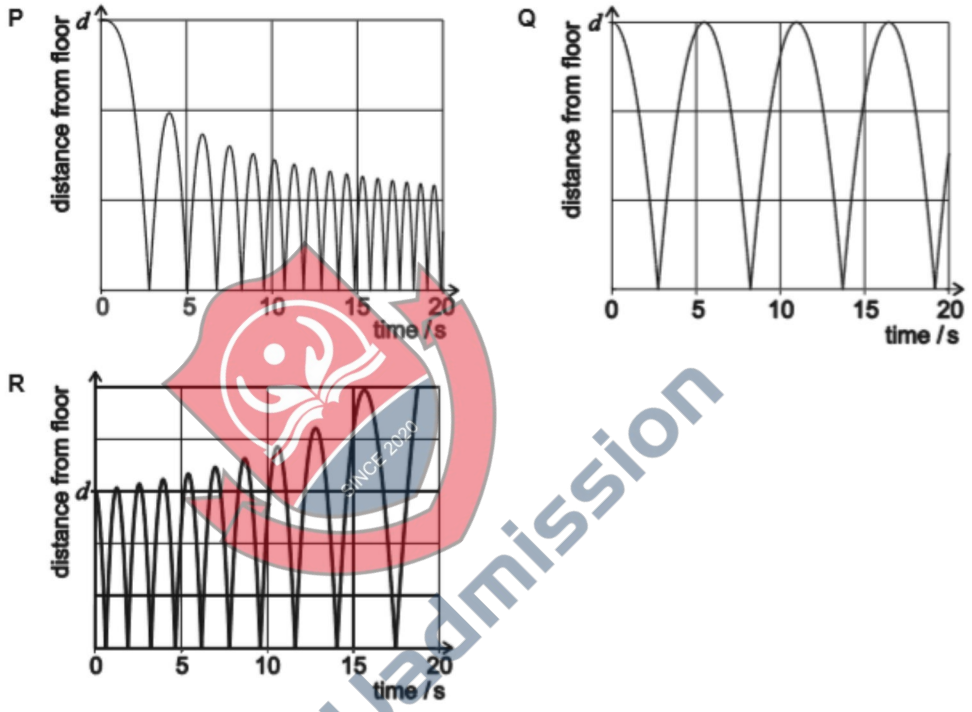
B Q only

C R only

D P and Q only

E Q and R only

c) The ball bounces and hits the floor repeatedly. Which of these graphs might represent the position of the ball plotted against time? **[3 marks]**



- Q not possible as ball has downward acceleration
- Downward acceleration increases with time
- So the accelerating force on the ball before bounce is smaller than the decelerating force on it after bounce
- So max height reached after each bounce must decrease
- Graph P is correct

Answer is A

d)

d) Force is usually measured in Newtons (N). Given that $F = ma$, which of the following is an alternative unit for force? **[1 mark]**

A $kg\,s\,m^{-2}$

B $kg^{-1}\,m^{-1}\,s^{2}$

C $kg\,m\,s^{-2}$

D $N\,kg^{-1}\,m^{-1}\,s^{2}$

E $N^{-1}\,kg\,m\,s^{-2}$

F = ma

- m has unit kg
- a $= \frac{dv}{dt}$, so as v has units ms^{-1}, a has unis ms^{-2}
- So F has units $Kgms^{-2}$

Answer is C

e)

e) Air is now injected into the spacecraft, creating air resistance. The drag force D on the ball is given by

$$D = \frac{1}{2} X \rho v^2 A$$

where ρ is the air density, v is the ball's speed, A is its cross-sectional area and X is an unknown parameter.

What are the units of X? **[2 marks]**

A ms^{-2}

B ms^{-1}

C $kg^{-1}\,m^{-1}\,s^{2}$

D $kg\,m\,s^{-2}$

E X has no units

- D is a force so has units $kgms^{-2}$
- $\rho = \frac{m}{v}$, so has units $Kgms^{-3}$
- V has units ms^{-1}, so v^2 m^2s^{-2}
- A has units m^2
- $x = \frac{2D}{\rho V^2 A}$, so has units

$$\frac{kgmS^{-2}}{kgm^{-3}\,m^{2}\,S^{-2}\,m^{2}}$$

$$= \frac{m^{1}}{m^{1}}$$

$$= 1$$

So x has no units

Answer is E