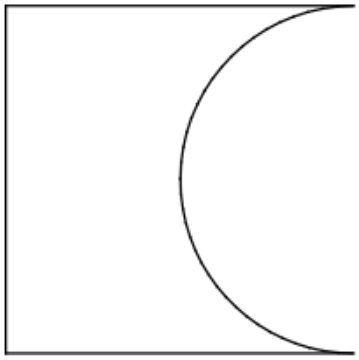
Worked Solutions for ENGAA Past Papers

ENGAA Specimen S1 - Question 1

1 A square piece of metal has a semicircular piece cut out of it as shown. The area of the remaining metal is $100\,\text{cm}^2$.



[diagram not to scale]

Which one of the following is a correct expression for the length of the side of the square in centimetres?

A $20\sqrt{\frac{2}{8-\pi}}$

B $10\sqrt{\frac{2}{4-\pi}}$

C $20\sqrt{\frac{2}{8+\pi}}$

D $10\sqrt{\frac{1}{8-\pi}}$

E $20\sqrt{\frac{1}{4-\pi}}$

ENGAA Specimen S1 - Question 1 - Worked Solution

Let the side length of the square $= S$

The radius of the semicircle $= \frac{S}{2}$

$$S^2 - \frac{\pi\left(\frac{S}{2}\right)^2}{2} = 100$$

$$S^2\left(1 - \frac{\pi}{8}\right) = 100$$

$$S^2 = \frac{100}{1-\frac{\pi}{8}}$$

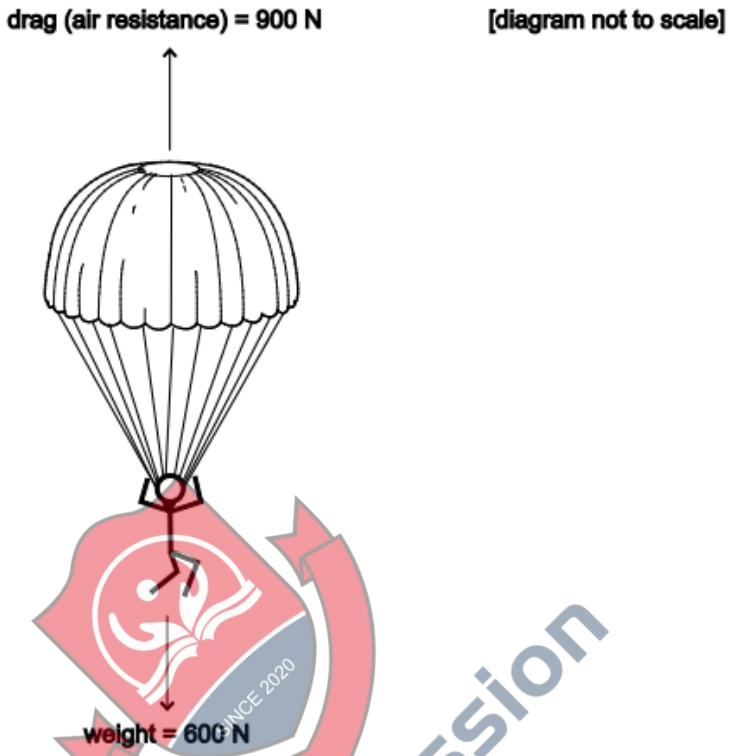
$$= \frac{800}{8-\pi}$$

$$S = \sqrt{\frac{800}{8-\pi}} = 20\sqrt{\frac{2}{8-\pi}}$$

Answer is A

ENGAA Specimen S1 - Question 2

2 Shortly after opening her parachute, a free-fall parachutist of mass 60 kg (including equipment) experiences the forces shown in the diagram.



Which line in the table gives the size and direction of the acceleration of the parachutist at this instant?

	size of acceleration / m s^{-2}	*direction of acceleration*
A	5.0	downwards
B	10.0	downwards
C	5.0	upwards
D	10.0	upwards
E	0.0	—

ENGAA Specimen S1 - Question 2 - Worked Solution

$$\sum F = ma$$

$$900 - 600 = 60a$$

$$a = 5.0ms^{-2} \ \ upwards$$

Answer is C

ENGAA Specimen S1 - Question 3

3 If you look at a clock and the time is 9.45, what is the angle between the hour and the minute hands?

A 0°

B 7.5°

C 15°

D 22.5°

E 30°

ENGAA Specimen S1 - Question 3 - Worked Solution

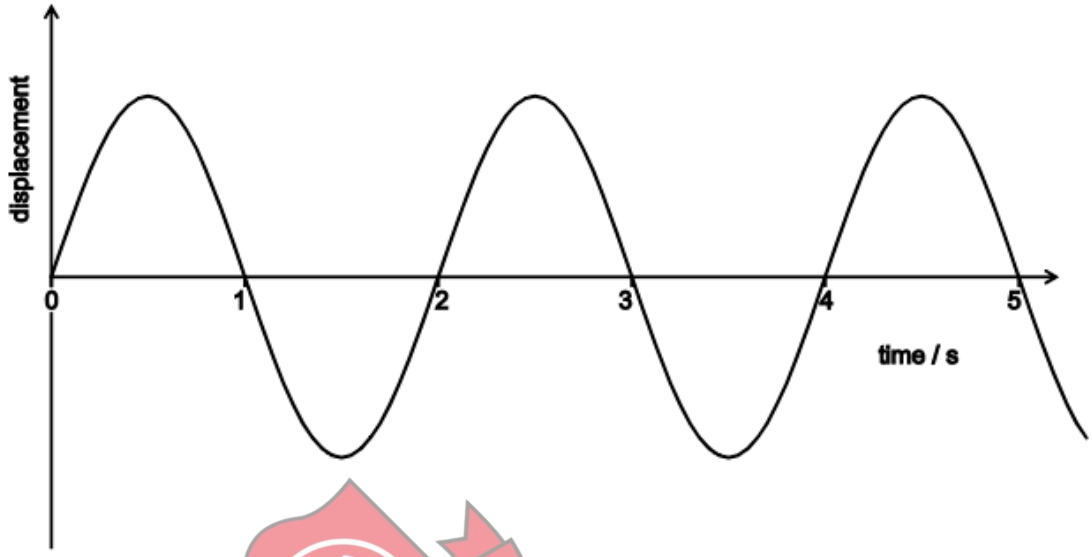
The minute hand is pointing at 9. The hour hand is somewhere between 9 and 10.
The angle between 9 and 10 is 30°. It takes 60 minutes for the hour hand to travel from 9 to 10.
Therefore in 45 minutes, it travels:

$$\frac{45}{60} \times 30° = 22.5°$$

Answer is D

ENGAA Specimen S1 - Question 4

4 The displacement/time graph shown represents a wave of wavelength 1.5 cm.



What is the speed of the wave?

A $0.33\,\text{cm}\,\text{s}^{-1}$

B $0.67\,\text{cm}\,\text{s}^{-1}$

C $0.75\,\text{cm}\,\text{s}^{-1}$

D $1.33\,\text{cm}\,\text{s}^{-1}$

E $1.5\,\text{cm}\,\text{s}^{-1}$

F $3.0\,\text{cm}\,\text{s}^{-1}$

ENGAA Specimen S1 - Question 4 - Worked Solution

The period of the wave, T=2.0s

$$f = \frac{1}{T} = 0.5Hz$$

$$v = f\lambda$$

$$v = 0.5 \times 1.5$$

$$v = 0.75cms^{-1}$$

Answer is C

ENGAA Specimen S1 - Question 5

5 Which of the expressions below has the largest value for $0 < x < 1$?

A $\frac{1}{x}$

B x^2

C $\frac{1}{(1+x)}$

D $\frac{1}{\sqrt{x}}$

E $\sqrt{x}$

ENGAA Specimen S1 - Question 5 - Worked Solution

Let's first consider the range of each of the options:

$$0 < x < 1$$

$$0 < x^2 < 1$$

$$0 < \sqrt{x} < 1$$

$$\frac{1}{x} > 1$$

$$\frac{1}{\sqrt{x}} > 1$$

$$\frac{1}{1+x} < 1$$

We can see from this that it is either **Option A** or **Option D**

$$x < \sqrt{x} \text{ as } \sqrt{x} \text{ is less than } 1. \quad Thus, \quad \frac{1}{x} > \frac{1}{\sqrt{x}}$$

$$\frac{1}{x} \text{ has the greatest value over } 0 < x < 1$$

Answer is A

ENGAA Specimen S1 - Question 6

6 Which of the following is a correct unit of potential difference (voltage)?

A amp per ohm

B coulomb per joule

C joule per second

D newton per coulomb

E watt per amp

ENGAA Specimen S1 - Question 6 - Worked Solution

$E = QV$, $V = IR$, $P = IV$

Write out equations that use voltage

Look at the units and see what correspond to possible answers.

$V = \frac{P}{I}$ $=>$ $\frac{Watt}{Amp}$

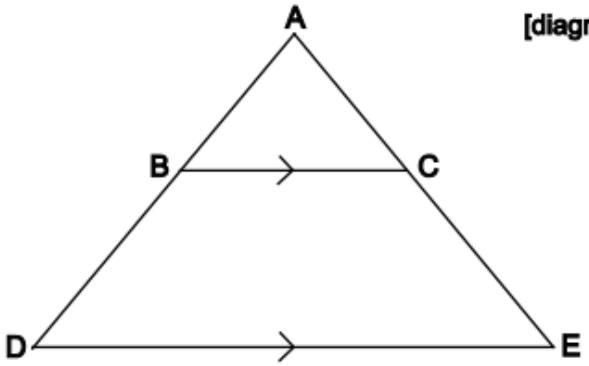
Answer is E

ENGAA Specimen S1 - Question 7

7 A shape is formed by drawing a triangle ABC inside the triangle ADE.

BC is parallel to DE.

AB = 4 cm BC = x cm DE = $x + 3$ cm DB = $x - 4$ cm



[diagram not to scale]

Calculate the length of DE.

A 5 cm

B 7 cm

C 9 cm

D $4+2\sqrt{7}$ cm

E $7+2\sqrt{7}$ cm

ENGAA Specimen S1 - Question 7 - Worked Solution

Triangle ADE and Triangle ABC are similar so $\frac{DE}{AD} = \frac{BC}{AB}$

$$AD = AB + DB$$

$$= 4 + (x - 4)$$

$$= x\,cm$$

$$\frac{x-3}{x} = \frac{x}{4}$$

$$x^2 = 4(x + 3)$$

$$x^2 - 4x - 12 = 0$$

$$(x + 2)(x - 6) = 0$$

$$x = 6\ cm\ \ (x\ cannot\ be\ negative)$$

$$DE = x + 3 = 9cm$$

Answer is C

ENGAA Specimen S1 - Question 8

8 A ball is thrown vertically upwards and leaves the thrower's hand with a speed of $12\,m\,s^{-1}$. You may assume that all of the initial kinetic energy of the ball has been converted into gravitational potential energy when the ball reaches its highest point.

What is the height above the thrower's hand to which it rises?

(gravitational field strength = $10\,N\,kg^{-1}$)

A 7.2 m

B 14.4 m

C 24 m

D 60 m

E 120 m

ENGAA Specimen S1 - Question 8 - Worked Solution

Assuming no air resistance,

$\frac{1}{2}mv^2 = mgh_f \quad (KE = GPE)$

where h_f denotes the final height.

$h_f = \frac{v^2}{2g}$

$= \frac{12^2}{20}$

$= 7.2m$

Answer is A

ENGAA Specimen S1 - Question 9

9 Two variables are connected by the relation: $P \propto \frac{1}{Q^2}$

Q is increased by 40%.

To the nearest percent, describe the change in P in percentage terms.

A 29% decrease

B 44% decrease

C 49% decrease

D 51% decrease

E 80% decrease

F 96% decrease

ENGAA Specimen S1 - Question 9 - Worked Solution

$$P \propto \frac{1}{Q^2}$$

$$Q' = 1.4Q$$

$$P' = \frac{P}{1.4^2}$$

$$= \frac{P}{1.96} = 0.51P$$

this correspond to a ~49% decrease

Answer is C

ENGAA Specimen S1 - Question 10

10 A lorry of mass m, and travelling initially at speed v along a horizontal road, is brought to rest by an average horizontal braking force F in time t.

Ignoring any other resistive forces, what distance is travelled by the lorry during this time?

(gravitational field strength $= g$)

A $\frac{F}{mg}$

B $\frac{mgv}{F}$

C $\frac{mv^2}{2F}$

D $\frac{v^2}{2g}$

E vt

F $2vt$

ENGAA Specimen S1 - Question 10 - Worked Solution

$$F = ma \qquad a = \frac{\Delta v}{\Delta t}$$

$$a = \frac{F}{m} = -\frac{v}{t}$$

$$s = vt - \frac{1}{2}at^2 \qquad one\ can\ use\ suvats$$

$$Note\ that\ v\ in\ this\ equation\ is\ the\ final\ velocity\ and\ is\ equal\ to\ 0.$$

$$t = -\frac{vm}{F}$$

$$s = 0 - \frac{1}{2}\frac{F}{m}\left(\frac{-vm}{F}\right)^2$$

$$= -\frac{v^2 m}{2F}$$

$$distance = |s|$$

$$= \frac{mv^2}{2F}$$

Answer is C

ENGAA Specimen S1 - Question 11

11 Three variables x, y and z are known to be related to each other in the following ways:

x is directly proportional to the square of z.
y is inversely proportional to the cube of z.

Which of the following correctly describes the relationship between x and y?

A The square of x is directly proportional to the cube of y.

B The square of x is inversely proportional to the cube of y.

C The cube of x is directly proportional to the square of y.

D The cube of x is inversely proportional to the square of y.

E x is directly proportional to y^6.

ENGAA Specimen S1 - Question 11 - Worked Solution

$x \propto z^2$, $y \propto \frac{1}{z^3}$ *which can be rewritten as* $x = kz^2$, $y = \frac{c}{z^3}$

cubing the 1*st equation:* $x^3 = k^3 z^6$ *squaring the second equation:* $y^2 = \frac{c^2}{z^6}$

multiplying these two equations with each other gives $x^3 y^2 = k^3 c^2 = constant$

$x^3 \propto \frac{1}{y^2}$

Answer is D

ENGAA Specimen S1 - Question 12

12 Nuclide ${}^{N}_{R}X$ is an unstable isotope which decays in two stages into nuclide Z as shown:

$$ {}^{N}_{R}X \rightarrow {}^{P}_{R-2}Y \rightarrow {}^{P}_{Q}Z $$

What are the values of P and Q?

(Consider only alpha and beta decays.)

	P	Q
A	$N - 4$	$R + 1$
B	$N - 4$	$R - 1$
C	$N - 4$	$R - 2$
D	N	$R - 1$
E	N	$R - 2$
F	N	$R - 4$

ENGAA Specimen S1 - Question 12 - Worked Solution

$RNX \rightarrow R - 2PY \rightarrow QPZ$

Since the proton number of Y is 2 less than that of X,

$X \rightarrow Y$ *by alpha decay*

hence $P = N - 4$

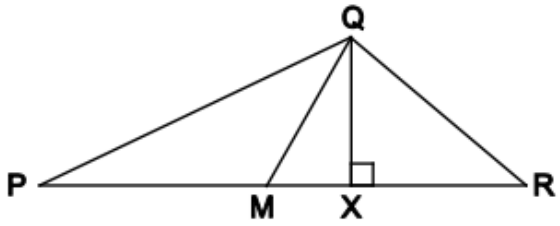
Since the mass number of Z is equal **to** that of Y , it decays by beta decay.

hence $Q = R - 2 + 1 = R - 1$

Answer is B

ENGAA Specimen S1 - Question 13

13 In the triangle PQR shown below:



[diagram not to scale]

X lies on PR

$\angle$QXR is 90°

$\frac{QX}{PX} = \frac{1}{6}$

$\frac{QX}{XR} = \frac{2}{3}$

M is the midpoint of PR.

What is $\frac{QX}{MX}$?

A $\frac{1}{9}$

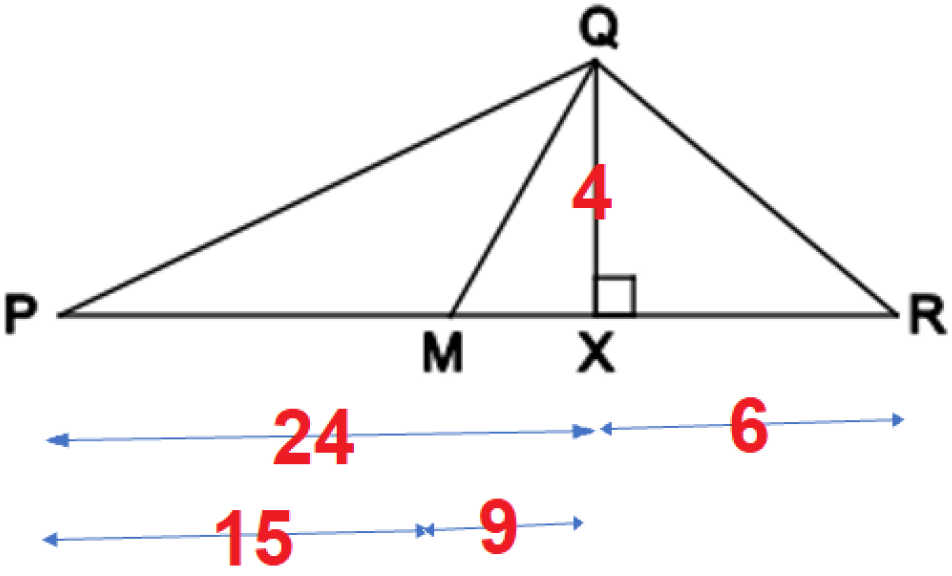
B $\frac{5}{12}$

C $\frac{4}{9}$

D $\frac{1}{2}$

E $\frac{5}{6}$

ENGAA Specimen S1 - Question 13 - Worked Solution



Let QX be 4 (You can set any number for this. 4 is just used here to ensure all the other lengths are integers.)

From the information given in the question, we can see that PX is 24 and XR is 6. Therefore, PR is 30. Since M is the midpoint of PR, PM = 30/2 = 15. Therefore, as seen in the diagram.

$MX = 24 - 15 = 9$. Therefore the $\frac{QX}{MX} = \frac{4}{9}$

Answer is C

ENGAA Specimen S1 - Question 14

14 A pulse of frequency 100 kHz is emitted from an ultrasound scanner, and is reflected from a foetus 10 cm below the transmitter placed on the mother's abdomen. The speed of sound within the mother's body is 500 m s^{-1}.

How long after its emission from the scanner does it take for the pulse to reach the receiver which is adjacent to the transmitter?

A 0.20 ms

B 0.40 ms

C 0.50 ms

D 0.80 ms

E 1.0 ms

ENGAA Specimen S1 - Question 14 - Worked Solution

The pulse travels to the foetus and back, totaling 20cm

$t = \frac{d}{v} = \frac{20\times10^{-2}}{500} = 4\times10^{-2}s = 0.40ms$

Answer is B

ENGAA Specimen S1 - Question 15

15 Solve the inequality $x^2 \geq 8 - 2x$

A $x \geq 4$

B $x \leq 2$ and $x \geq -4$

C $x \geq -2$ and $x \leq 4$

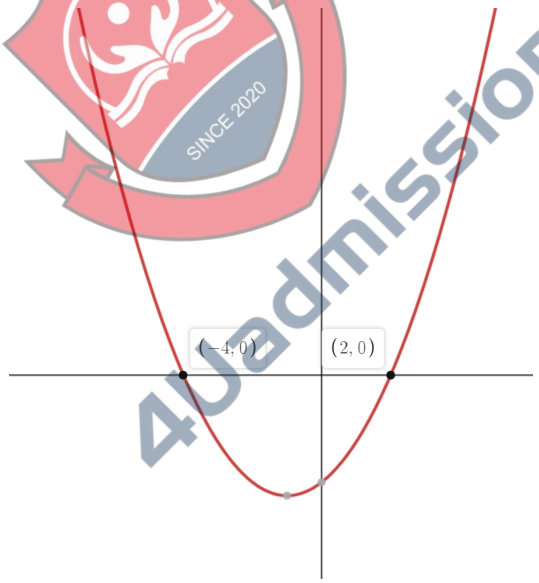
D $x \geq 2$ or $x \leq -4$

ENGAA Specimen S1 - Question 15 - Worked Solution

$$x^2 \geq 8 - 2x$$

$$x^2 + 2x - 8 \geq 0$$

$$(x + 4)(x - 2) \geq 0$$

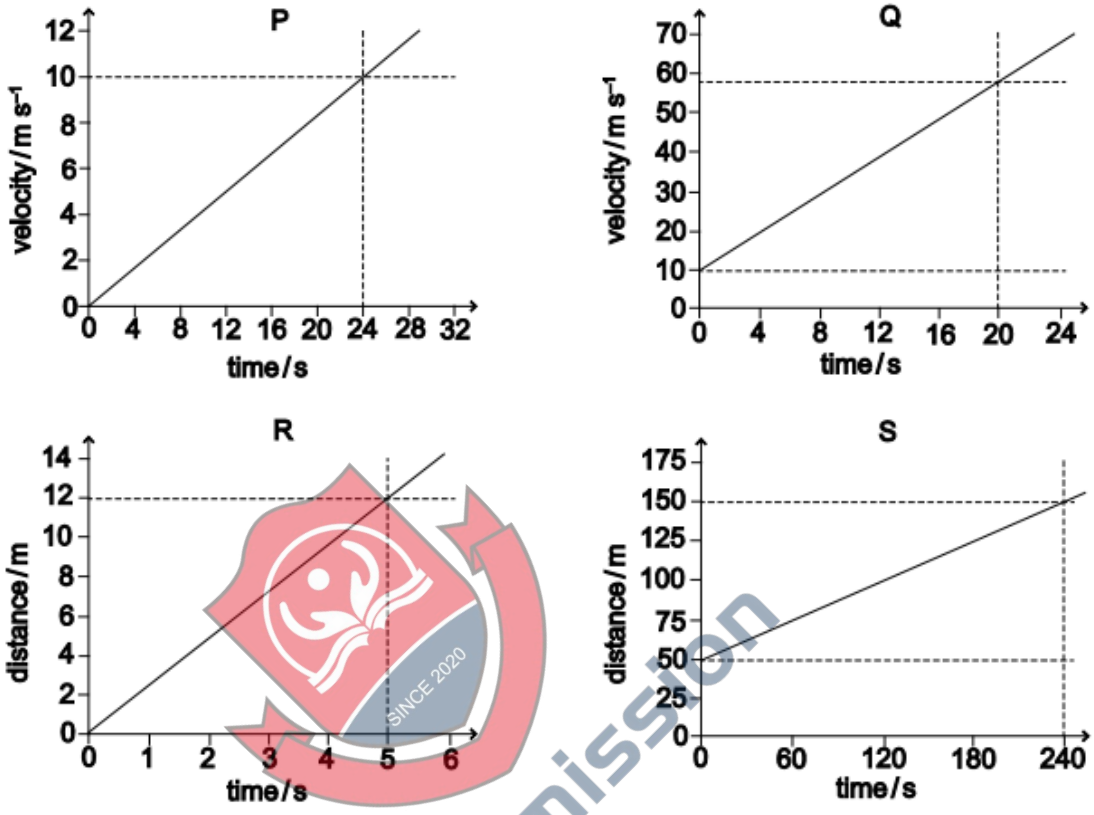


$$x \leq -4, \; x \geq 2$$

Answer is D

ENGAA Specimen S1 - Question 16

16 The diagrams below show either velocity-time or distance-time graphs for four different objects, P, Q, R and S.



Which graph(s) show an object accelerating at 2.4 m s^{-2}?

A P only

B Q only

C R only

D S only

E P and Q only

F Q and R only

G P and S only

ENGAA Specimen S1 - Question 16 - Worked Solution

$$a = \frac{\Delta v}{\Delta t}$$

Therefore acceleration is the gradient on a velocity-time graph.

$$P : a = \frac{10-0}{24} \neq 2.4ms^{-2}$$

$$Q : a = \frac{58-10}{20} = 2.4ms^{-2}$$

R & S give distance time graph and so the gradient represents velocity. Since the graphs are straight and gradient is constant, velocity is constant and there is no acceleration.

Q only

Answer is B

ENGAA Specimen S1 - Question 17

17 The total surface area of a cylinder, measured in square centimetres, is numerically the same as its volume, measured in cubic centimetres.

The radius of the cylinder is r cm, the height is h cm.

Express h in terms of r.

A $h = \dfrac{2r}{r-2}$

B $h = \dfrac{2r}{r+2}$

C $h = r+2$

D $h = r-2$

E $h = 2r(r-2)$

ENGAA Specimen S1 - Question 17 - Worked Solution

$$V = \pi r^2 h$$

$$SA = 2\pi r^2 + 2\pi r h = 2\pi r(r + h)$$

$$2\pi r(r + h) = \pi r^2 h$$

$$2(r + h) = hr$$

$$2r + 2h = rh$$

$$(2 - r)h + 2r = 0$$

$$h = -\frac{2r}{2-r} = \frac{2r}{r-2}$$

Answer is A

ENGAA Specimen S1 – Question 18

18 Two resistors with resistance R_1 ohms and R_2 ohms are connected in series with a battery that has a voltage V across its terminals.

Which formula gives the power dissipated by the resistor with resistance R_1 ohms?

A $\dfrac{VR_1}{R_1 + R_2}$

B $\dfrac{V^2R_1}{R_1 + R_2}$

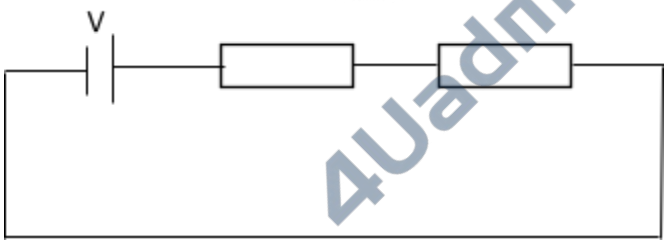
C $\dfrac{VR_1}{(R_1 + R_2)^2}$

D $\dfrac{V^2R_1}{(R_1 + R_2)^2}$

E $\dfrac{VR_1^2}{(R_1 + R_2)}$

F $\dfrac{V^2R_1^2}{(R_1 + R_2)^2}$

ENGAA Specimen S1 - Question 18 - Worked Solution



$$R_T = R_1 + R_2$$

$$I = \frac{V}{R_T}$$

$$P_1 = I^2 R_1$$

$$P_1 = \frac{V^2}{(R_1 + R_2)^2} R_1$$

Answer is D

ENGAA Specimen S1 - Question 19

19 The square PQRS is positioned so that its vertices are at the points with coordinates: $(1, 1)$, $(-1, 1)$, $(-1, -1)$ and $(1, -1)$.

The square is rotated clockwise through 90° about the origin and then reflected in the line $y = x$.

Which transformation will return the square to its original orientation?

A A reflection in the x-axis.

B A reflection in the y-axis.

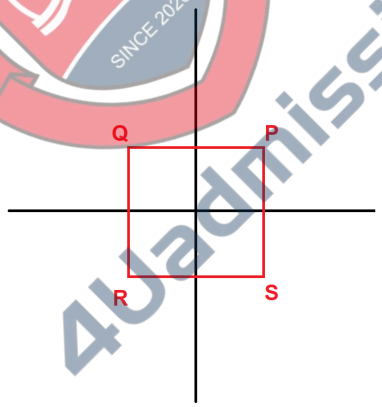
C A reflection in the line $y = -x$.

D A rotation of 90° clockwise about the origin.

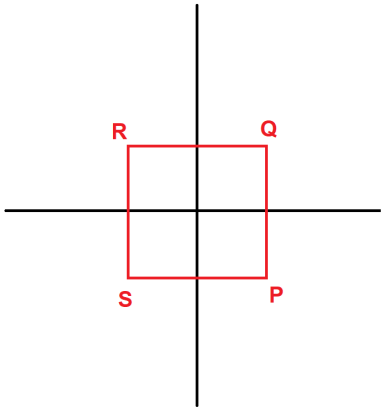
E A rotation of 90° anticlockwise about the origin.

ENGAA Specimen S1 - Question 19 - Worked Solution

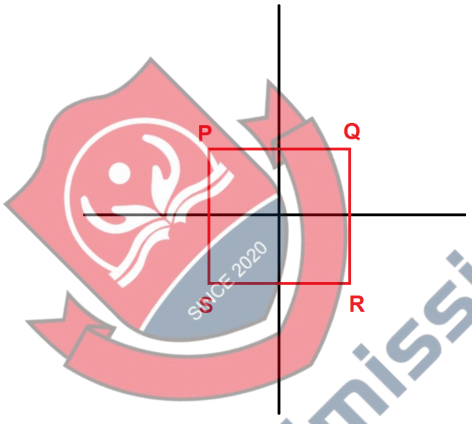
Originally, the square looks like this:



After the rotation of 90 degrees clockwise:



After a reflection in the line $y = x$:



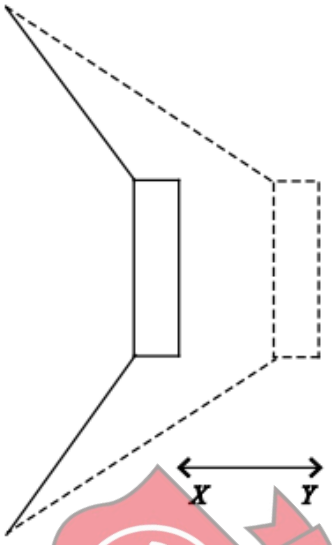
A reflection of this in the y-axis will return this square to the original position.

Answer is B

ENGAA Specimen S1 - Question 20

20 A sound wave is produced by a loudspeaker cone, which creates pulses of pressure by moving back and forth between two points X and Y as shown in the diagram.

[diagram not to scale]



The distance between points X and Y is 5.0 mm and the loudspeaker produces pulses of high pressure every 0.20 milliseconds.

The following statements about the sound wave produced are made:

P It has a speed of $25\,m\,s^{-1}$.

Q It has an amplitude of 5.0 mm.

R It has a wavelength of 5.5 mm.

S It has a frequency of 5.0 kHz.

Which of these statements can be correctly deduced from the information given?

A P only

B S only

C P and Q only

D P and R only

E Q and S only

F R and S only

G P, R and S only

ENGAA Specimen S1 - Question 20 - Worked Solution

$T = 0.2ms = 2\times10^{-4}s$

$f = \frac{1}{T} = \frac{1}{2\times10^{-4}} = 5000Hz = 5kHz$

We have no information about the speed of the waves.
We know the frequency but no way to know the wavelength
Answer is B

ENGAA Specimen S1 - Question 21

21 Which one of the following is a simplification of $\frac{x^2-4}{x^2-2x}$ where $x \neq 2$ and $x \neq 0$?

A $\frac{x-4}{x-2}$

B $\frac{x-2}{x}$

C $\frac{2}{x}$

D $\frac{x+2}{x}$

E $\frac{x+2}{x+1}$

ENGAA Specimen S1 - Question 21 - Worked Solution

$\frac{x^2-4}{x^2-2x} = \frac{(x+2)(x-2)}{x(x-2)} = \frac{x+2}{x}$ if $x \neq 2$, $x \neq 0$

Answer is D

ENGAA Specimen S1 - Question 22

22 Particle P has a fixed mass of 2 kg and particle Q has a fixed mass of 5 kg.

The two particles are moving in opposite directions along a straight line on a smooth plane.

Particle P has a speed of 3 m s^{-1} and particle Q has a speed of r m s^{-1}.

The particles collide directly. After the collision the direction of each particle is reversed.

The speed of P is now 1 m s^{-1} and the speed of Q is halved.

What is the value of r?

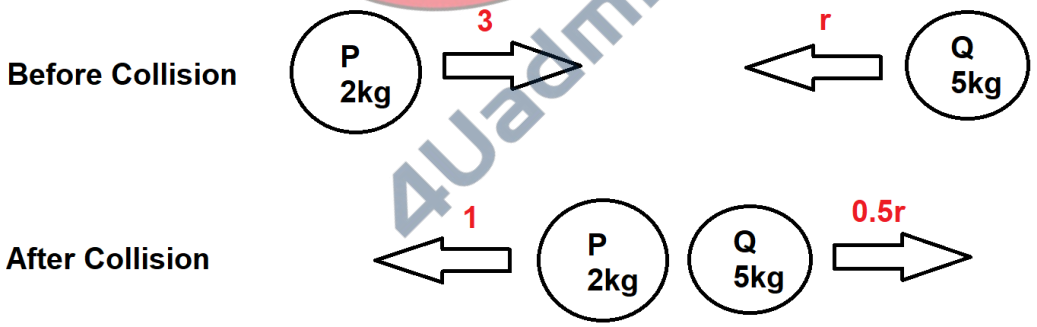
A $\frac{8}{15}$

B $\frac{14}{15}$

C $\frac{16}{15}$

D $\frac{8}{3}$

E $\frac{16}{5}$



ENGAA Specimen S1 - Question 22 - Worked Solution

Conservation of Momentum:

Total momentum before collision = Total momentum after collision

$$2\times3 + 5\times(-r) = 2\times(-1) + 5\times(0.5r)$$

$$7.5r = 8$$

$$r = \frac{8}{7.5} = \frac{16}{15}$$

Answer is C

ENGAA Specimen S1 - Question 23

23 Given that $a^x b^{2x} c^{3x} = 2$, where a, b, and c are positive real numbers, then $x =$

A $\log_{10}\left(\frac{2}{a+2b+3c}\right)$

B $\frac{\log_{10} 2}{\log_{10}(a+2b+3c)}$

C $\frac{2}{\log_{10}(a+2b+3c)}$

D $\frac{2}{a+2b+3c}$

E $\log_{10}\left(\frac{2}{ab^2c^3}\right)$

F $\frac{\log_{10} 2}{\log_{10}(ab^2c^3)}$

G $\frac{2}{\log_{10}(ab^2c^3)}$

H $\frac{2}{ab^2c^3}$

ENGAA Specimen S1 - Question 23 - Worked Solution

$$a^x b^{2x} c^{3x} = 2$$

Take logs

$$\log log\, a^x + \log log\, b^{2x} + \log log\, c^{3x} = \log log\, 2$$

$$x \log log\, a + 2x \log log\, b + 3x \log log\, c = \log log\, 2$$

$$x(\log log\, a + 2 \log log\, b + 3 \log log\, c) = \log log\, 2$$

$$x\left(\log log\, ab^2c^3\right) = \log log\, 2$$

$$x = \frac{2}{\left(ab^2c^3\right)}$$

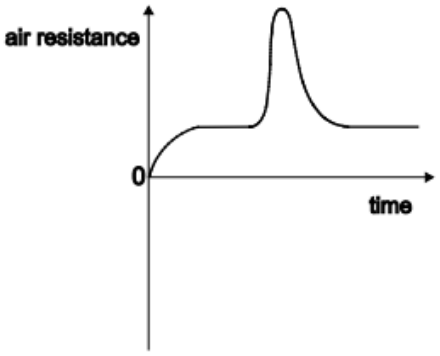
Answer is F

ENGAA Specimen S1 - Question 24

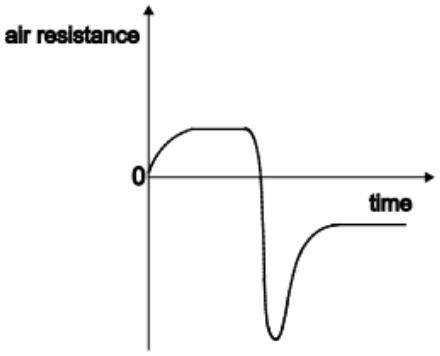
24 A parachutist falls from an aircraft and reaches a terminal velocity. After a while he opens his parachute and reaches a new (lower) terminal velocity.

Which graph shows how the total air resistance (drag) force acting on him and the parachute varies with time during the fall?

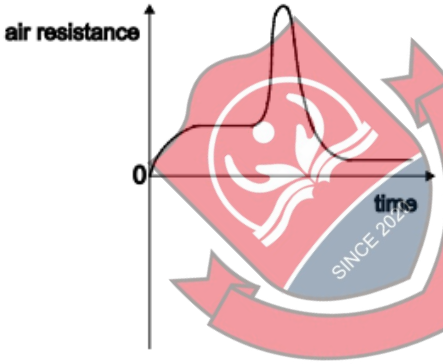
A



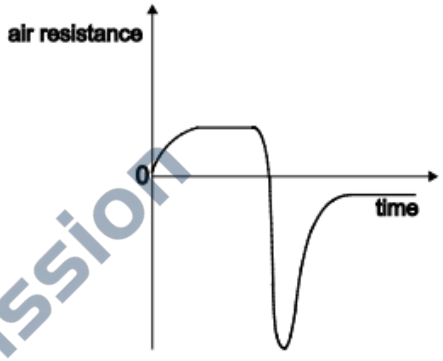
B



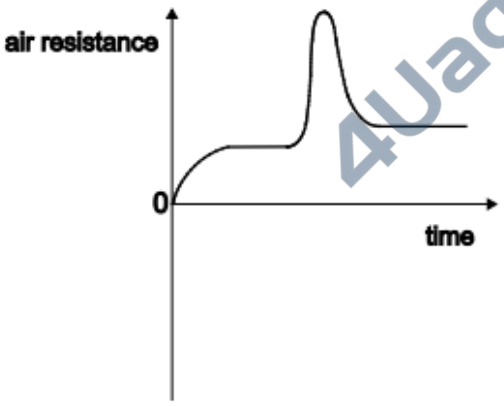
C



D



E



ENGAA Specimen S1 - Question 24 - Worked Solution

At terminal velocity air resistance = weight,
Therefore air resistance is same for both terminal velocities.
Answer is A

ENGAA Specimen S1 - Question 25

25 Which one of the following numbers is largest in value?

(All angles are given in radians.)

A $\tan\left(\frac{3\pi}{4}\right)$

B $\log_{10} 100$

C $\sin^{10}\left(\frac{\pi}{2}\right)$

D $\log_2 10$

E $\left(\sqrt{2}-1\right)^{10}$

ENGAA Specimen S1 - Question 25 - Worked Solution

$$\tan tan \frac{3\pi}{4} = -1$$

$$100 = 2$$

$$sin^{10}\left(\frac{\pi}{2}\right) = 1$$

$$10 > 3 \; as \; we \; know \; that \; (8) = 3$$

$$\left(\sqrt{2}-1\right)^{10} < 1 \; since \; we \; know \; that \; \left(0 < \left(\sqrt{2}-1\right) < 1\right)$$

Answer is D

ENGAA Specimen S1 - Question 26

26 A heavy block of stone rests on a rough, horizontal surface.

The block is subject to a horizontal force that increases from zero at a constant rate.

Assume that the coefficient of friction is greater than zero and that its value is independent of whether or not the block is moving.

What happens to the block of stone?

(Assume air resistance is negligible.)

A It moves forwards immediately and accelerates forwards with a constant acceleration.

B It remains stationary at first and then accelerates forwards with a constant acceleration.

C It remains stationary at first and then accelerates forwards with an increasing acceleration.

D It moves forwards immediately with a constant velocity.

E It remains stationary at first and then moves forwards with a constant velocity.

ENGAA Specimen S1 - Question 26 - Worked Solution

The box remains stationary until the force can overcome friction

$\sum F = ma$

As F increases, a also increases
So the acceleration increases
Answer is C

ENGAA Specimen S1 - Question 27

27 The sum of the roots of the equation $2^{2x} - 8 \times 2^{x} + 15 = 0$ is

A 3

B 8

C $2\log_{10} 2$

D $\log_{10}\left(\frac{15}{4}\right)$

E $\frac{\log_{10} 15}{\log_{10} 2}$

ENGAA Specimen S1 - Question 27 - Worked Solution

$$2^{2x} - 8 \times 2^{x} + 15 = 0$$

$$let\ 2^{x} = u$$

$$u^{2} - 8u + 15 = 0$$

$$(u - 5)(u - 3) = 0$$

$$u = 5\,,\ u = 3$$

$$2^{x} = 5\,,\ 2^{x} = 3$$

$$5 + 3 = 15$$

$$n = \frac{n}{a}$$

$$15 = \frac{15}{2}$$

Answer is E

ENGAA Specimen S1 - Question 28

28 A white billiard ball of mass 0.20 kg is travelling horizontally at 3.0 m s^{-1} and hits a red billiard ball of the same mass which is at rest. After the collision the white ball continues in the same direction with a speed of 1.0 m s^{-1}.

What is the speed of the red ball immediately after the collision?

A 1.0 m s^{-1}

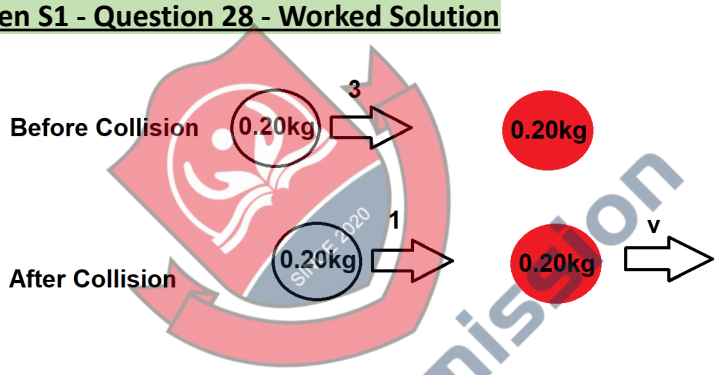
B 1.5 m s^{-1}

C 2.0 m s^{-1}

D 2.5 m s^{-1}

E 3.0 m s^{-1}

ENGAA Specimen S1 - Question 28 - Worked Solution



Conservation of momentum:

$$m\times 3 + m\times 0 = m\times 1 + m\times v$$

$$v = 2ms^{-1}$$

Answer is C

ENGAA Specimen S1 - Question 29

29 How many real roots does the equation $x^4 - 4x^3 + 4x^2 - 10 = 0$ have?

A 0

B 1

C 2

D 3

E 4

ENGAA Specimen S1 - Question 29 - Worked Solution

The turning points are:
$(0\,,\ -10)\,,\ (1\,,\ -9)\ and\ (2\,,\ -10)$

Due to the shape of quartics, we can know $(1\,,\ -9)$ is a local maximum and $(2\,,\ -10)$ are minimum.
The curve therefore only intersects the x axis twice and have 2 real roots.
Answer is C

ENGAA Specimen S1 - Question 30

30 A certain planet has no atmosphere. The planet has a gravitational field strength at its surface of g_p N kg^{-1}; this value is considered constant for this question. A rock is projected vertically upwards from the surface of the planet at an initial speed of 20 m s^{-1}. The rock reaches a maximum height h metres.

Which option shows a possible correct pair of values for g_p and h?

(Consider only gravitational forces.)

A $g_p = 5.0$; $h = 4.0$

B $g_p = 5.0$; $h = 40$

C $g_p = 10$; $h = 2.0$

D $g_p = 20$; $h = 1.0$

E $g_p = 20$; $h = 20$

ENGAA Specimen S1 - Question 30 - Worked Solution

If all kinetic energy is converted to GPE as no air resistance:

$$\frac{1}{2}mv^2 = mgh$$

$$v^2 = 2gh$$

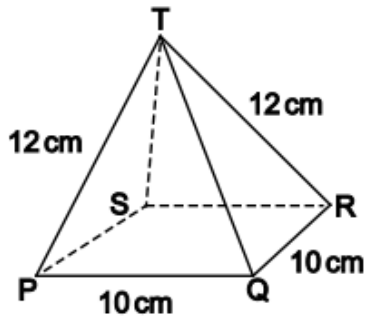
$$v = 20ms^{-1} \quad (initial\ speed)$$

$$h = \frac{200}{g}\ ,\ g = \frac{200}{h}$$

Answer is B

ENGAA Specimen S1 - Question 31

31 A box is a hollow pyramid. The base of the box is a square with sides 10 cm and all the slant edges of the box are 12 cm long.



[diagram not to scale]

What is the angle made by the slant edge TP with the base PQRS?

A $\sin^{-1}\frac{2\sqrt{5}}{12}$

B $\sin^{-1}\frac{5}{12}$

C $\sin^{-1}\frac{5\sqrt{2}}{12}$

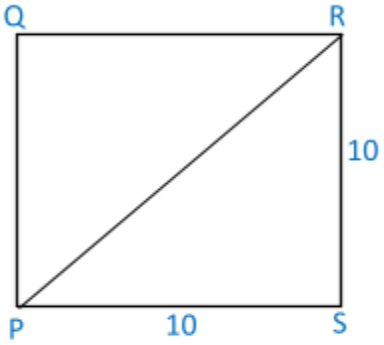
D $\cos^{-1}\frac{2\sqrt{5}}{12}$

E $\cos^{-1}\frac{5}{12}$

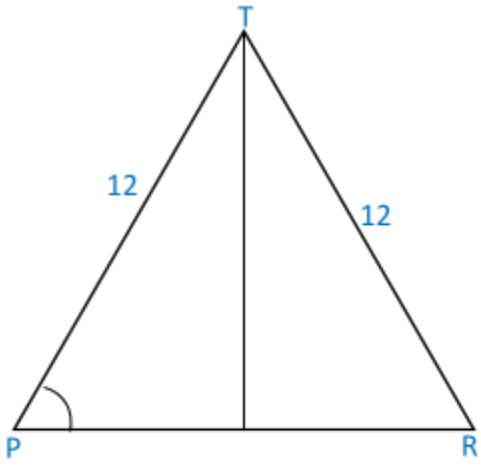
F $\cos^{-1}\frac{5\sqrt{2}}{12}$

ENGAA Specimen S1 - Question 31 - Worked Solution

Consider the base



Consider the pyramid stood up and one of the corners pointing



$$\cos\cos\theta = \frac{5\sqrt{2}}{12}$$

$$\theta = \left(\frac{5\sqrt{2}}{12}\right)$$

Answer is F

ENGAA Specimen S1 - Question 32

32 A man of weight 600 N stands on a set of accurate weighing scales in a moving elevator (lift). The reading on the scales is 480 N.

Which statement correctly describes the motion of the elevator?

A The elevator is moving downwards with constant speed.

B The elevator is moving downwards with decreasing speed.

C The elevator is moving upwards with increasing speed.

D The elevator is moving upwards with constant speed.

E The elevator is moving upwards with decreasing speed.

ENGAA Specimen S1 - Question 32 - Worked Solution

The elevator is accelerating downwards as the scales are exerting less than 600N reaction force on the man.
NB: This does not mean the elevator is moving downwards
Answer is E

ENGAA Specimen S1 - Question 33

33 The variables x and y and the constants a and b are real and positive. The variables x and y are related.

A graph of $\log y$ against $\log x$ is drawn.

For which one of the following relationships will this graph be a straight line?

A $y^6 = a^x$

B $y = ab^x$

C $y^2 = a + x^b$

D $y = ax^b$

E $y^x = a^b$

ENGAA Specimen S1 - Question 33 - Worked Solution

$$let \ \log log \ y \ = Y \ and \ \log log \ x \ = X$$

$$Y = mX + c$$

$$\log log \ y \ = m \log log \ x \ + c$$

$$y = cx^m \quad or \quad ax^6$$

Answer is D

ENGAA Specimen S1 - Question 34

34 The track for a tram is straight and horizontal. A tram is travelling along the track at a velocity of $12.0\,\mathrm{m\,s^{-1}}$ when the brakes are applied. Because of this, the tram decelerates to rest at a constant rate of $1.50\,\mathrm{m\,s^{-2}}$.

What is the distance travelled by the tram over the total time for which it is decelerating?

A 18.0 m

B 48.0 m

C 96.0 m

D 108 m

E 216 m

ENGAA Specimen S1 - Question 34 - Worked Solution

$$v^2 = u^2 + 2as$$

$$v = 0$$

$$u = 12.0$$

$$a = -1.50$$

$$s = \frac{v^2 - u^2}{2a}$$

$$= \frac{-12.0^2}{-2 \times 1.50}$$

$$= \frac{144}{3}$$

$$= 48.0m$$

Answer is B

ENGAA Specimen S1 - Question 35

35 A triangle is to be drawn with sides that are integer lengths in centimetres, and a total perimeter of 12 cm.

How many different (non-congruent) triangles can be drawn?

A 1

B 2

C 3

D 10

E 12

ENGAA Specimen S1 - Question 35 - Worked Solution

In a triangle, the length of the longest side cannot exceed nor equal the sum of the lengths of the other 2 sides.
Therefore the longest possible side length is 5cm
This gives 2 – 5 - 5 and 3 – 4 – 5.
There is also 4 – 4 -4.
There are no other combinations
3 possible triangles
Answer is C

ENGAA Specimen S1 - Question 36

36 A particle of weight 5 N is held in position by two light ropes.

One of the ropes makes an angle of 60° with the upward vertical, the other is horizontal.

What is the tension in the horizontal rope?

A $1.25\sqrt{3}$ N

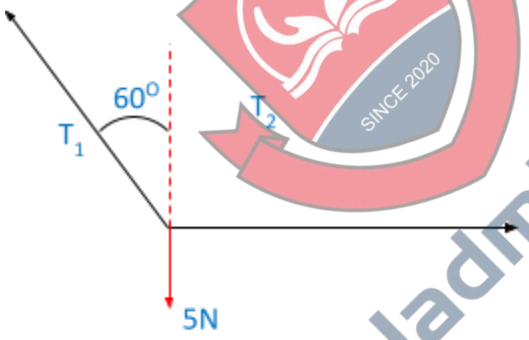
B 5 N

C $5\sqrt{3}$ N

D 10 N

E $10\sqrt{3}$ N

ENGAA Specimen S1 - Question 36 - Worked Solution



$$T_1 \cos cos\ 60 = 5N$$

$$T_1 \sin sin\ 60 = T_2$$

$$T_2 = \frac{5}{\cos cos\ 60} \sin sin\ 60$$

$$= 5 \tan tan\ 60°$$

$$= 5\sqrt{3}\ N$$

Answer is C

ENGAA Specimen S1 - Question 37

37 The triangle PQR has a right angle at R.

The length of PQ is 4 cm, correct to the nearest centimetre.

The length of PR is 2 cm, correct to the nearest centimetre.

Find the minimum possible length, in centimetres, of QR.

A $\sqrt{6} - \frac{1}{2}$

B $2\sqrt{3} - \frac{1}{2}$

C $2\sqrt{5} - \frac{1}{2}$

D $2\sqrt{5}$

E $2\sqrt{3}$

F $\sqrt{6}$

ENGAA Specimen S1 - Question 37 - Worked Solution

$(PR)^2 + (QR)^2 = (PQ)^2$

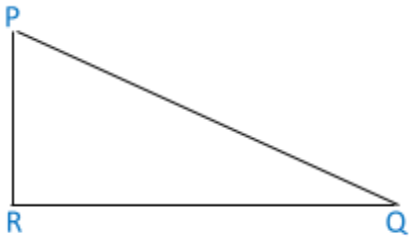
$To\ find\ QR_{min}: Use\ PQ_{min}\ and\ PR_{max}$

$PR_{max} = 2.5cm$

$PQ_{min} = 4.5cm$

$2.5^2 + (RQ)^2 = 4.5^2$

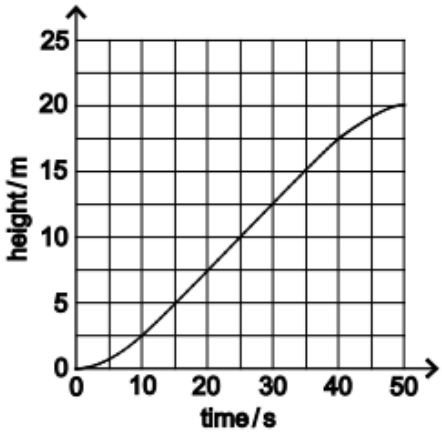
$RQ = \sqrt{6}cm$



Answer is F

ENGAA Specimen S1 - Question 38

38 The graph shows the variation with time of the height through which a crane lifts a mass of 20 kg.



What is the power output of the crane when the mass is at a height of 10 m?

(gravitational field strength = 10 N kg^{-1}, the effects of air resistance and friction are negligible)

A 0.1 W

B 10 W

C 40 W

D 100 W

E 400 W

F 4000 W

ENGAA Specimen S1 - Question 38 - Worked Solution

$$P = \frac{\Delta E}{\Delta t} = mg\frac{\Delta h}{\Delta t} = 20 \times 10 \times \frac{5}{10} = 100w$$

Answer is D

ENGAA Specimen S1 - Question 39

39 The angle x is measured in radians and is such that $0 \le x \le \pi$.

The total length of any intervals for which $-1 \le \tan x \le 1$ and $\sin 2x \ge 0.5$ is

A $\frac{\pi}{12}$

B $\frac{\pi}{6}$

C $\frac{\pi}{4}$

D $\frac{\pi}{3}$

E $\frac{5\pi}{12}$

F $\frac{\pi}{2}$

G $\frac{5\pi}{6}$

ENGAA Specimen S1 - Question 39 - Worked Solution

$-1 \le \tan tan\, x \le 1$ *is satisfied when* $0 \le x \le \frac{\pi}{4}$ *and* $\frac{3\pi}{4} \le x \le \pi$

$\sin sin\, 2x \ge 0.5$ *is satisfied when* $\frac{\pi}{6} \le 2 \le \frac{5\pi}{6}$ *so* $\frac{\pi}{12} \le x \le \frac{5\pi}{12}$

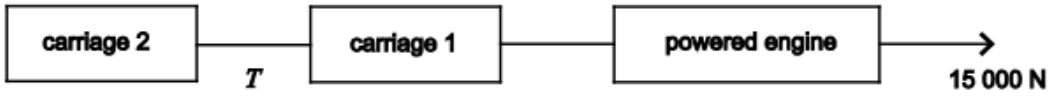
both are satisfied for $\frac{\pi}{12} \le x \le \frac{\pi}{4}$

the length of the interval $= \frac{\pi}{6}$

Answer is B

ENGAA Specimen S1 - Question 40

40 A train consists of a powered engine travelling horizontally pulling two unpowered carriages.



The engine has a mass of 20 000 kg, and each carriage has a mass of 5000 kg. When the engine accelerates from rest it develops a thrust (driving force) of 15 000 N as shown.

Ignoring resistive forces, what is the tension (pulling force) T in the light and inextensible coupling between carriage 1 and carriage 2?

A 2500 N

B 3750 N

C 5000 N

D 7500 N

E 15 000 N

ENGAA Specimen S1 - Question 40 - Worked Solution

$\sum F = ma \; on \; the \; whole \; train$

$15000 = (20000 + 5000 + 5000)a$

$a = \frac{15000}{30000} = 0.5ms^{-2}$

Focusing on carriage 2

$\sum F = ma$

$T = 5000 \times 0.5$

$T = 2500 \; N$

Answer is A

SECTION 2

ENGAA Specimen S2 - Question 1

1 A wave of single frequency is travelling through a medium at a speed of $60\,\text{cm}\,\text{s}^{-1}$.

Each of the oscillating particles in the medium takes 0.20 seconds to move from its equilibrium position to its next maximum displacement.

What is the wavelength of the wave?

A 12 cm

B 24 cm

C 48 cm

D 75 cm

E 150 cm

F 300 cm

ENGAA Specimen S2 - Question 1 - Worked Solution

$$T = 4 \times 0.20s$$

$$T = 0.80s$$

$$f = \frac{1}{T} = 5Hz$$

$$v = f\lambda$$

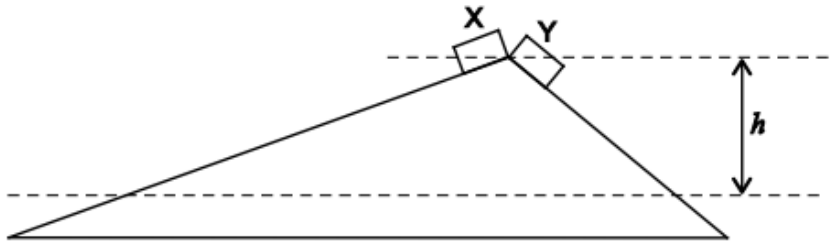
$$\lambda = \frac{v}{f} = \frac{60}{5} = 12cm$$

Answer is A

ENGAA Specimen S2 - Question 2

2 Two identical wooden blocks X and Y are released from rest from the top of two frictionless slopes. Block Y is on a steeper slope than block X.

The times taken for each block to fall through the same vertical distance h are t_X and t_Y respectively, and at these times the blocks have speeds v_X and v_Y.



Which of the following options gives the relationships between times and speeds for blocks X and Y?

A $t_X = t_Y$ and $v_X = v_Y$

B $t_X > t_Y$ and $v_X < v_Y$

C $t_X = t_Y$ and $v_X > v_Y$

D $t_X > t_Y$ and $v_X = v_Y$

E $t_X > t_Y$ and $v_X > v_Y$

F $t_X = t_Y$ and $v_X < v_Y$

ENGAA Specimen S2 - Question 2 - Worked Solution

The speed will be the same after a given height change because gravitational potential energy I turned into kinetic energy and there is no friction.
Block X takes longer as it moves a further distance

$$t_x > t_y \, , \; v_x = v_y$$

Answer is D

ENGAA Specimen S2 - Question 3

3 A space probe is travelling through the vacuum of deep space in a straight line at constant speed; its engine is switched off and there are no gravitational forces acting on it.

Fuel in the probe explodes and the probe splits into two sections. One section continues on at a speed greater than the speed of the probe before the explosion whilst the other section travels on more slowly than before.

Which statement is correct?

A Both the total kinetic energy and the total momentum after the explosion are the same as before.

B The total energy after the explosion is the same as before but the total kinetic energy has decreased.

C The total energy after the explosion is the same as before but the total momentum has increased.

D The total kinetic energy after the explosion is the same as before but the total momentum has decreased.

E The total kinetic energy after the explosion is the same as before but the total momentum has increased.

F The total momentum after the explosion is the same as before but the total kinetic energy has decreased.

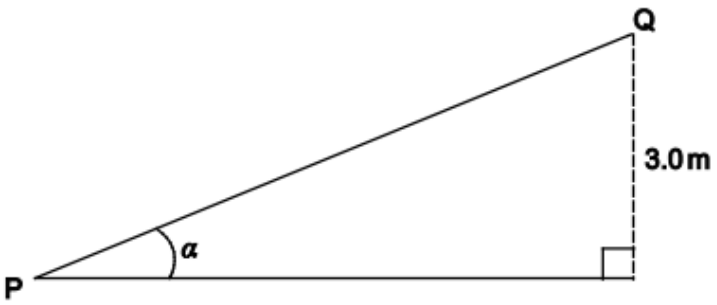
G The total momentum after the explosion is the same as before but the total kinetic energy has increased.

ENGAA Specimen S2 - Question 3 - Worked Solution

Energy from the explosion is transferred into kinetic energy as kinetic energy increases.
Momentum is conserved.
Answer is G

ENGAA Specimen S2 - Question 4

4 PQ is a rough plane which is inclined to the horizontal at an angle α, where $\tan\alpha = \frac{3}{4}$
The point Q is a vertical distance of 3.0 m above the horizontal level of P.



A small object of mass 5.0 kg is projected from P along a line of greatest slope of the plane towards Q.

The object loses 210 J of kinetic energy as it travels from P to Q.

What is the friction force between the plane and the object as it travels from P to Q?

(gravitational field strength = 10 N kg^{-1}; air resistance can be ignored)

A 12 N

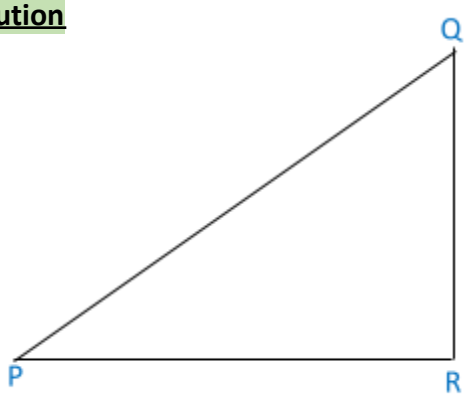
B 15 N

C 39 N

D 42 N

E 72 N

ENGAA Specimen S2 - Question 4 - Worked Solution



$\tan tan\,\alpha = \frac{3}{4}$

$QR = 3m$

$PR = 4m$

$PQ = 5m$

$energy = force \times distance$

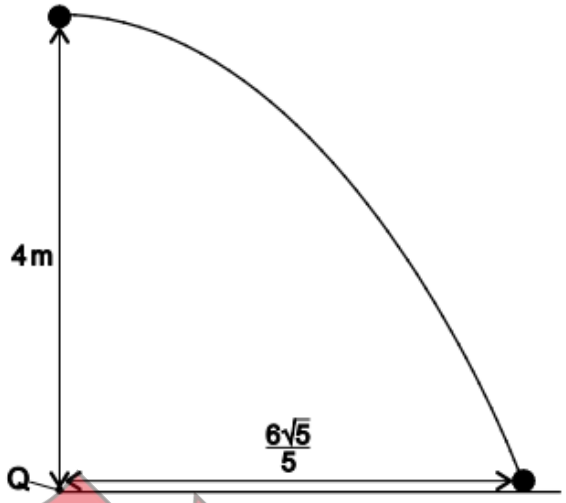
$210 = F_R \times 5$

$F_K = 42N$

Answer is D

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 6

6 A wire of length 4.0 m with a uniform cross-sectional area of 0.020 mm^2 is connected in series with a 1.0 kΩ resistor.

There is a pd of 1.2 V across this arrangement and a voltmeter connected across the 1.0 kΩ resistor reads 1.0 V.

Under these conditions, what is the resistivity of the material from which the wire is made?

A $1.0 \times 10^{-6}\ \Omega m$

B $1.1 \times 10^{-5}\ \Omega m$

C $1.0 \times 10^{-3}\ \Omega m$

D $1.1 \times 10^{-2}\ \Omega m$

E $8.0 \times 10^{-2}\ \Omega m$

F $8.0 \times 10^{2}\ \Omega m$

G $4.0 \times 10^{7}\ \Omega m$

H $4.0 \times 10^{10}\ \Omega m$

ENGAA Specimen S2 - Question 6 - Worked Solution

Since the wire in series with the resistor, the sum of the p. d. s is 1.2v
The p . d across the wire = 0.2v

$$for\ resistors\ in\ series\quad \frac{V_1}{V_2} = \frac{R_1}{R_2}$$

$$\frac{0.2}{1.0} = \frac{R}{1.0\times10^{3}}$$

$$R = 200\Omega$$

$$R = \frac{Pl}{A}$$

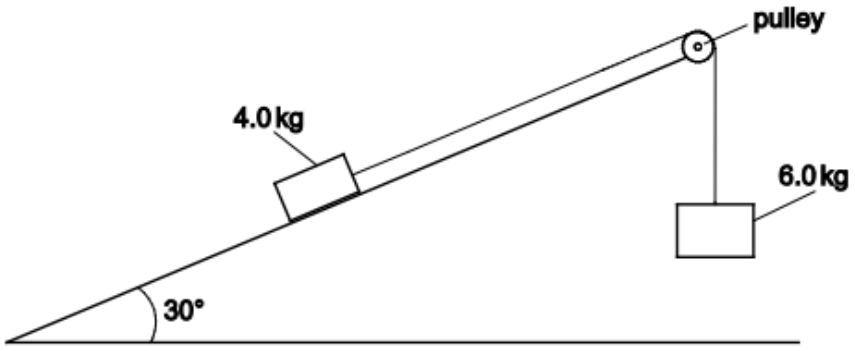
$$\frac{P\times4.0}{0.02\times10^{-6}} = 200$$

$$P = 1\times10^{-6}\Omega m$$

Answer is A

ENGAA Specimen S2 - Question 7

7 A block of mass 4.0 kg is on a rough plane which is inclined at 30° to the horizontal. The block is attached to one end of a light inextensible string, the other end of which is attached to a block of mass 6.0 kg. The rope passes over a frictionless pulley of negligible mass at the top of the plane, and the 6.0 kg mass hangs vertically, as shown in the diagram.



The friction force acting on the 4.0 kg block is 15.0 N.

What is the acceleration of the 4.0 kg block?

A $0.50\,ms^{-2}$

B $2.5\,ms^{-2}$

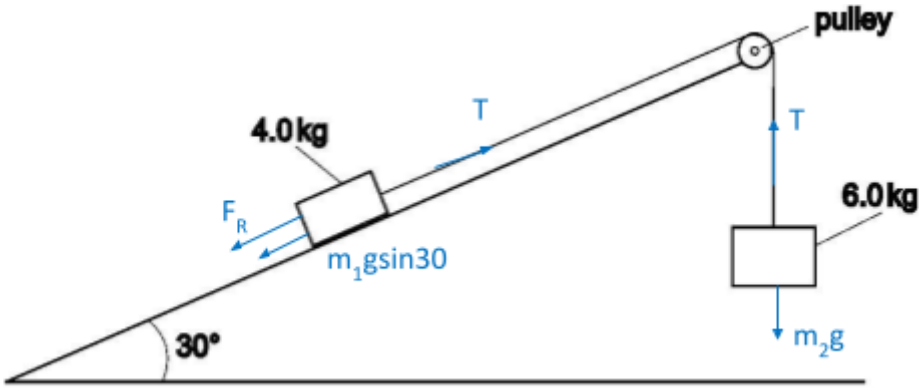
C $4.5\,ms^{-2}$

D $5.5\,ms^{-2}$

E $6.25\,ms^{-2}$

F $8.75\,ms^{-2}$

ENGAA Specimen S2 - Question 7 - Worked Solution



$4.0kg\ block$:

$$T - F_R - m_1 g \sin sin\,\theta = m_1 a$$

$$T - 15 - 4{\times}10{\cup}\frac{1}{2} = 4a$$

$$T - 35 = 4a \quad ----- \textcircled{1}$$

$6.0kg\ block$:

$$m_2 g - T = m_2 a$$

$$6{\times}10 - T = 6a$$

$$60 - T = 6a \quad --- \textcircled{2}$$

$$\textcircled{1} + \textcircled{2}$$

$$25 = 10a$$

$$a = 2.5$$

$sub\ into\ \textcircled{1}$

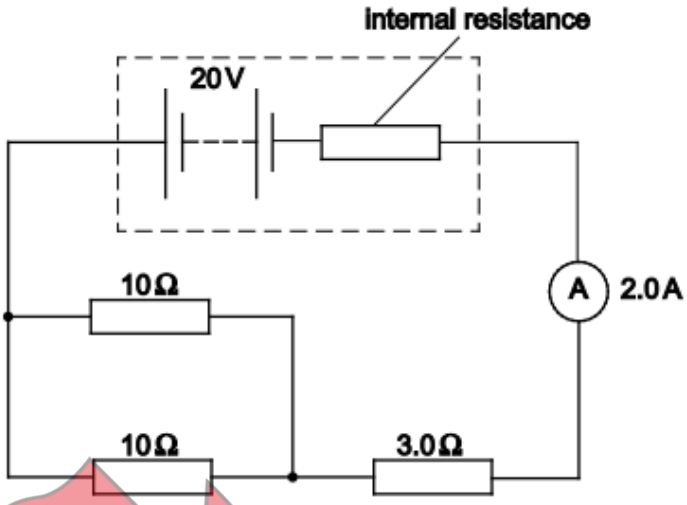
$$T - 35 = 10$$

$$T = 45N$$

Answer is B

ENGAA Specimen S2 - Question 8

8 The circuit shown includes a battery with an emf of 20V and an ideal ammeter. The reading on the ammeter is 2.0A.



What is the internal resistance of the battery?

A 2.0Ω

B 4.0Ω

C 7.0Ω

D 10Ω

E 18Ω

ENGAA Specimen S2 - Question 8 - Worked Solution

For resistors in parallel:

$$\frac{1}{R_e} = \sum_i \frac{1}{R_i}$$

$$\frac{1}{R_e} = \frac{1}{10} + \frac{1}{10}$$

$$R_e = 5\Omega$$

$$For\ resistors\ in\ series: R_T = \sum_i R_i$$

$$R_T = 5 + 3 + r$$

$$V = IR$$

$$20 = 2(8 + r)$$

$$r = 2\Omega$$

Answer is A

ENGAA Specimen S2 - Question 9

9 The main part of a telescope is made from three uniform cylindrical tubes each 20 cm long, joined end to end.

The tubes have masses 0.40 kg, 0.60 kg and 1.0 kg respectively.

The telescope rests horizontally on a single pivot and is in equilibrium.

How far from the lighter end of the telescope is the pivot?

A 30 cm

B 34 cm

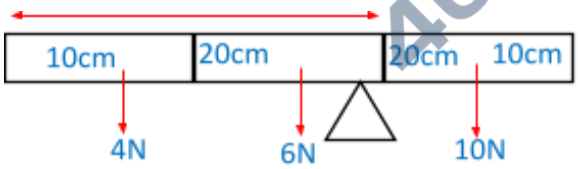
C 36 cm

D 40 cm

E 45 cm

ENGAA Specimen S2 - Question 9 - Worked Solution

Start with a diagram



Take moments about P

$$4(x - 10) + 6(x - 30) = 10(50 - x)$$

$$4x - 40 + 6x - 60 = 500 - 10x$$

$$20x = 600$$

$$x = 30cm$$

Answer is A

ENGAA Specimen S2 - Question 10

10 A heavy boulder is being dragged across a rough horizontal surface at constant velocity of $0.20\,m\,s^{-1}$ by four steel cables connected in parallel with one another. Each cable has a cross-sectional area of $2.0\,cm^2$ and is under a constant elastic strain of 0.0025

What is the total power being transferred by the cables?

(Young modulus of steel = 2.0×10^{11} Pa)

A 20 kW

B 25 kW

C 80 kW

D 100 kW

E 400 kW

F 800 MW

G 1.0 GW

H 4.0 GW

ENGAA Specimen S2 - Question 10 - Worked Solution

$$Stress = \frac{Force}{Area}$$

$$Young\ modulus,\ E = \frac{stress}{strain}$$

$$Force = E \times strain \times area$$

$$= 2.0 \times 10^{11} \times 0.0025 \times 2.0 \times 10^{-4}$$

$$= 1.0 \times 10^{5} N$$

$$there\ are\ 4\ cables\ so\ the\ total\ force = 4.0 \times 10^{5} N$$

$$Powe = force \times velocity$$

$$= 4 \times 10^{5} \times 0.2 = 8 \times 10^{4} w$$

Answer is C

ENGAA Specimen S2 - Question 11

11 A seismic wave causes the surface of the Earth to vibrate. The vibration at a building some distance from the epicentre of the earthquake has a period of 2.0 s.

A second building is 1.0 km farther from the epicentre. The vibration at the second building is $\pi/3$ radians out of phase with that at the first building.

What is the speed of the wave?

(Assume that the wavelength is greater than the separation of the buildings.)

A $\frac{1.5}{\pi}\,\text{km s}^{-1}$

B $\frac{3.0}{\pi}\,\text{km s}^{-1}$

C $1.5\,\text{km s}^{-1}$

D $\frac{6.0}{\pi}\,\text{km s}^{-1}$

E $3.0\,\text{km s}^{-1}$

F $\frac{12.0}{\pi}\,\text{km s}^{-1}$

G $6.0\,\text{km s}^{-1}$

H $12\,\text{km s}^{-1}$

ENGAA Specimen S2 - Question 11 - Worked Solution

$$1.0km = \frac{\pi/3}{2\pi}\lambda = \frac{\lambda}{6}$$

$$\lambda = 6.0km$$

$$f = \frac{1}{T} = \frac{1}{2.0} = 0.5Hz$$

$$v = f\lambda$$

$$v = 0.5 \times 6$$

$$v = 3kms^{-1}$$

Answer is E

ENGAA Specimen S2 - Question 12

12 An object of mass m moving through air experiences an air resistance (drag) force F given by

$$F = kv^n$$

where k and n are positive constants.

The object is released from rest from a great height and falls vertically. No horizontal forces act on the object.

When it is travelling at a speed of v_0, its acceleration is 50% of the acceleration of free fall.

What is the terminal speed of the object?

A $2^n v_0$

B $2^{(1/n)} v_0$

C $2v_0$

D $2^{-n} v_0$

E $2^{-1} v_0$

F $2^{-(1/n)} v_0$

ENGAA Specimen S2 - Question 12 - Worked Solution

$$In\ freefall\ \ mg = ma\ \ ,\ \ a = g$$

$$at\ speed\ v_o,\ mg - kv_o^{\,n} = \frac{mg}{2}$$

$$\frac{mg}{2} = kv_o^{\,n}$$

$$At\ terminal\ speed\ v_t,\ mg - kv_t^{\,n} = 0$$

$$mg = kv_t^{\,n} = 2kv_o^{\,n}$$

$$v_t^{\,n} = 2v_o^{\,n}$$

$$v_t = 2^{\frac{1}{n}} v_o$$

Answer is B

ENGAA Specimen S2 - Question 13

13 Two identical springs each have an unstretched length of 12.0 cm, a spring constant k and negligible mass.

One spring is hung from a fixed point. A 100 g mass is hung from the lower end of the spring.

The second spring is attached to the base of the 100 g mass. A second 100 g mass is hung from the lower end of this second spring.

The combined length of the two springs (not including the heights of the masses) is now 30.0 cm. Neither spring exceeds its elastic limit.

What is the spring constant k?

(gravitational field strength = 10 Nkg^{-1})

A 0.10 Ncm^{-1}

B 0.17 Ncm^{-1}

C 0.25 Ncm^{-1}

D 0.33 Ncm^{-1}

E 0.50 Ncm^{-1}

F 0.67 Ncm^{-1}

G 1.0 Ncm^{-1}

ENGAA Specimen S2 - Question 13 - Worked Solution

$200g$ *are hung from the top spring and* $100g$ *from the bottom spring*

$$T_1 = 2N \qquad T_2 = 1N$$

$$x_1 = \frac{2}{k} \qquad x_2 = \frac{1}{k}$$

$$12 + \frac{2}{k} + 12 + \frac{1}{k} = 30$$

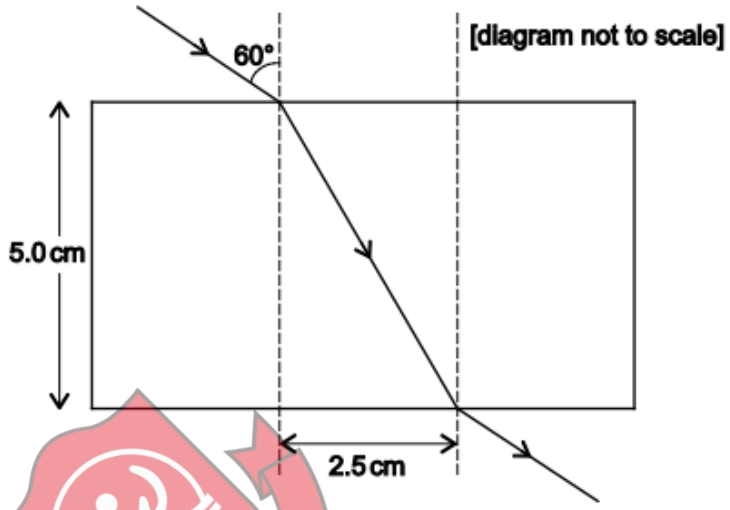
$$\frac{3}{k} = 6$$

$$k = 0.5Ncm^{-1}$$

Answer is E

ENGAA Specimen S2 - Question 14

14 A ray of light in air strikes the surface of a rectangular transparent block at an angle of 60° to the normal. The ray passes through the block and exits from the far side as shown. The width of the block is 5.0 cm and the distance between the normal at the point of entry to the block and the normal at the point of exit from the block is 2.5 cm.



What is the refractive index of the block?

A $\frac{2}{\sqrt{15}}$

B $\frac{1}{\sqrt{3}}$

C $\frac{1}{\sqrt{2}}$

D $\frac{2}{\sqrt{5}}$

E $\frac{\sqrt{5}}{2}$

F $\sqrt{2}$

G $\sqrt{3}$

H $\frac{\sqrt{15}}{2}$

ENGAA Specimen S2 - Question 14 - Worked Solution

$$\tan tan\,\theta = \frac{2.5}{5} = \frac{1}{2}$$

$$\sin sin\,\theta = \frac{1}{\sqrt{5}}$$

$$n_1 \sin sin\,\theta_1 = n_2 \sin sin\,\theta_2$$

$$\sin sin\,60 = n \times \frac{1}{\sqrt{5}}$$

$$n = \sin sin\,60 \times \sqrt{5} = \frac{\sqrt{15}}{2}$$

Answer is H

ENGAA Specimen S2 - Question 15

15 Two smooth spheres of masses 3 kg and 1 kg are moving towards each other along a straight line. Their speeds are $2\,\text{m s}^{-1}$ and $6\,\text{m s}^{-1}$ respectively. The spheres collide and separate.

As a result of the collision their total kinetic energy decreases by 25%.

What is the speed of the 1 kg sphere after the collision?

A $3\,\text{m s}^{-1}$

B $3\sqrt{3}\,\text{m s}^{-1}$

C $4\sqrt{3}\,\text{m s}^{-1}$

D $4.5\,\text{m s}^{-1}$

E $6\,\text{m s}^{-1}$

ENGAA Specimen S2 - Question 15 - Worked Solution

$conservation\ of\ p: 1\times6 - 3\times2 = 3v_2 - 1v_1$

$0 = 3v_1 - v_1$

$v_1 = 3v_2$

Kinetic energy

$\frac{1}{2}\times1\times{v_1}^2 + \frac{1}{2}\times3\times{v_2}^2 = 0.75\left(\frac{1}{2}\times1\times6^2 + \frac{1}{2}\times3\times2^2\right)$

$\frac{1}{2}\times\left(3v_2\right)^2 + \frac{3}{2}{v_2}^2 = 18$

$6{v_2}^2 = 18$

$v_2 = \sqrt{3}$

$v_1 = 3\sqrt{3}ms^{-1}$

Answer is B

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

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

$$Position\ of\ P \quad use\ suvats$$

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

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

$$= 3t^2$$

Position of Q

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

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

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

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

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

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

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

T must be +ve

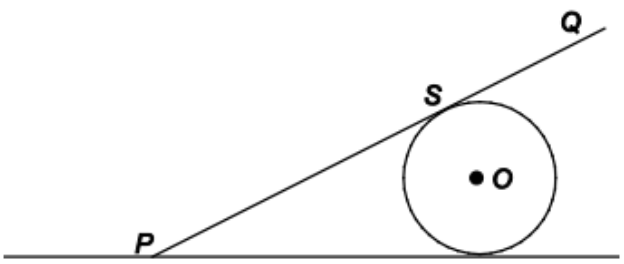
$$they\ meet\ at\ t = 3s$$

Answer is B

ENGAA Specimen S2 - Question 17

17 *PQ* is a thin, uniform rod of length 4 m and mass 5 kg.

[diagram not to scale]



A fixed, thin disc has radius 2 m and centre *O*.

P rests on a rough horizontal plane and *PQ* rests in equilibrium touching the disc at the point *S*.

The distance *PO* is 4 m.

The rod and the disc are in the same vertical plane, as in the diagram.

What is the normal contact force between the disc and the rod?

(gravitational field strength = g)

A $2.5g$

B $\frac{5\sqrt{3}g}{6}$

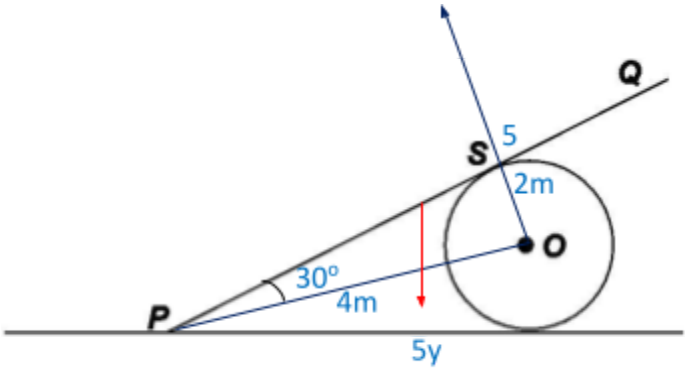
C $\frac{5\sqrt{3}g}{3}$

D $\frac{10\sqrt{3}g}{3}$

E $5g$

F $10g$

ENGAA Specimen S2 - Question 17 - Worked Solution



$$PS^2 + 2^2 = 4^2$$

$$PS = 2\sqrt{3}m$$

Taking moments about P:

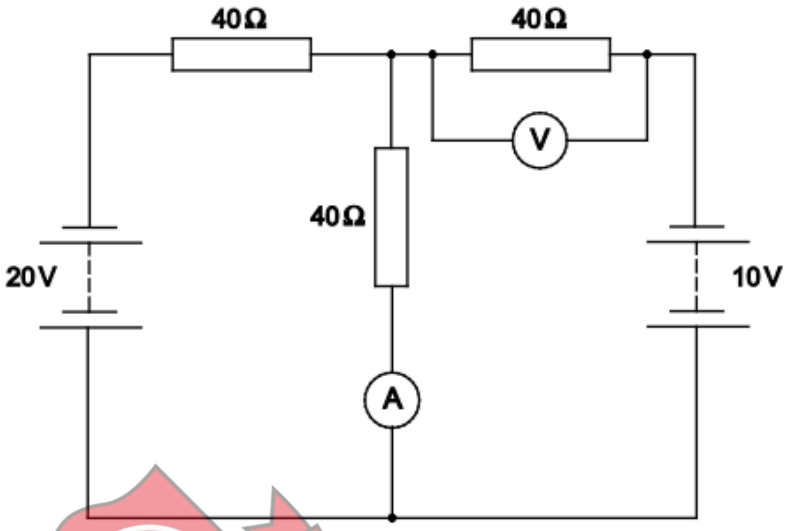
$$2\sqrt{3}N = 2\cos 60° \times 5g = 5g$$

$$N = \frac{5g}{2\sqrt{3}}$$

Answer is B

ENGAA Specimen S2 - Question 18

18 An electric circuit contains two different power supplies with negligible internal resistance, three identical resistors, an ideal ammeter and an ideal voltmeter.



What are the readings on the ammeter and the voltmeter?

What are the readings on the ammeter and the voltmeter?

	ammeter reading	*voltmeter reading*
A	0.25 A	0 V
B	0.50 A	0 V
C	0.75 A	0 V
D	0.25 A	10 V
E	0.50 A	10 V
F	0.75 A	10 V

ENGAA Specimen S2 - Question 18 - Worked Solution

Using Kirchoff's voltage law

$loop\ ①: I_1 \times 40 + I_3 \times 40 = 20 \quad ---- ①$

$loop\ ②: I_2 \times 40 + I_3 \times 40 = 10 \quad ---- ②$

Using Kirchoff's current law:

$I_1 + I_2 = I_3 \quad ---- ③$

① + ②

$(I_1 + I_2)40 + 2I_2 \times 40 = 30$ ———— ④

Sub ③ into ④

$120I_3 = 30$

$I_3 = \frac{3}{12} = 0.25a$

$40I_3 + 40I_2 = 10$

$10 + 40I_2 = 10$

$I_2 = 0$

$the\ voltmeter\ reading = 0V$

Answer is A

ENGAA Specimen S2 - Question 19

19 Water at the top of a waterfall has zero vertical velocity. The water falls 45 m vertically onto a flat horizontal rock of area 2.0 m^2.

Each second, 40 kg of water hits the rock.

When the water hits the rock it flows away horizontally.

At any instant the average depth of water on the rock surface is 0.050 m.

What is the total average pressure on the rock due to water?

(gravitational field strength = 10 N kg^{-1}; density of water = 1000 kg m^{-3}; assume air resistance is negligible)

A 400 Pa

B 500 Pa

C 600 Pa

D 1000 Pa

E 1100 Pa

F 1200 Pa

G 1700 Pa

H 2200 Pa

ENGAA Specimen S2 - Question 19 - Worked Solution

When the water hits the rock it loses all vertical velocity instantly.
40kg of water hits the rock every second
The velocity of the water can be found using conservation of energy:

$\frac{1}{2}mv^2 = mgh$

$v = \sqrt{2gh}$

$v = \sqrt{900} = 30ms^{-1}$

The momentum of water transferred to the rock every second

$= 40 \times 30 = \frac{1200Ns}{s} = 1200N$

$F = \frac{dp}{dt}$

The force on the rock is 1200N from water hitting it

$P_1 = 1200 \div 2 = 600Pa$

There is also pressure from water sitting on the rock

$P_2 = \rho gh$

$= 1000 \times 10 \times 0.050$

$= 500Pa$

$P_T = P_1 + P_2 = 1100Pa$

Answer is E

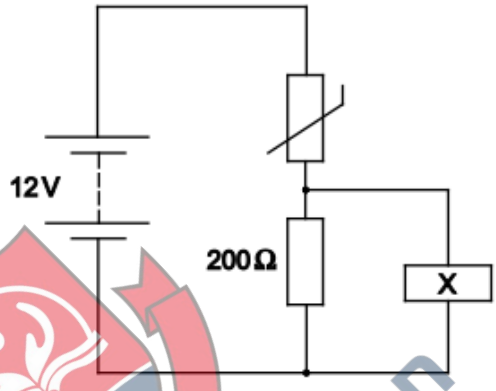
ENGAA Specimen S2 - Question 20

20 In the following circuit, the thermistor has a resistance R at temperature T °C given by the equation

$$R = R_0 b^{-\mu T}$$

where R_0 is the resistance at 0 °C, and μ is a positive constant and $b > 1$.

X is a component with very high resistance that emits light when the pd across it exceeds 2.0 V.



What is the full range of temperatures of the thermistor for which component X emits light?

A greater than $(1/\mu)(\log_b R_0 - \log_b 1000)$

B greater than $(1/\mu)(\log_b 1000 - \log_b R_0)$

C greater than $(1/\mu)(\log_b R_0 - \log_b 1200)$

D greater than $(1/\mu)(\log_b 1200 - \log_b R_0)$

E less than $(1/\mu)(\log_b R_0 - \log_b 1000)$

F less than $(1/\mu)(\log_b 1000 - \log_b R_0)$

G less than $(1/\mu)(\log_b R_0 - \log_b 1200)$

H less than $(1/\mu)\ (\log_b 1200 - \log_b R_0)$

ENGAA Specimen S2 - Question 20 - Worked Solution

Potential divider circuit can be used as the resistance of X is very high.

$$V_{out} = V_{in}\left(\frac{R_2}{R_1+R_2}\right)$$

$$V_x = 12\times\frac{200}{200+R_o b^{-\mu T}}$$

$$\frac{2400}{200+R_o b^{-\mu T}} > 2.0$$

$$1200 > 200 + R_o b^{-\mu T}$$

$$R_o b^{-\mu T} < 1000$$

$$b^{-\mu T} < \frac{1000}{R_o}$$

$$-\mu T \log log\, b < \log log\, 1000 - \log log\, R_o$$

$$\mu T \log log\, b > \log log\, R_o - \log log\, 1000$$

$$T > \frac{\log log\, b}{\mu}\left(\log log\, R_o - \log log\, 1000\right)$$

Make b the base of the logs such that $b = 1$

$$T > \frac{1}{\mu}\left(\log log\, R_o - \log log\, 1000\right)$$

Answer is A