UNIVERSITY OF CAMBRIDGE

ENGINEERING ADMISSIONS ASSESSMENT

Specimen Paper 60 minutes

SECTION 1

INSTRUCTIONS TO CANDIDATES

Please read these instructions carefully, but do not open this question paper until you are told that you may do so. This paper is Section 1 of 2.

A separate answer sheet is provided for this paper. Please check you have one. You also require a soft pencil and an eraser.

Please complete the answer sheet with your candidate number, centre number, date of birth, and name.

At the end of 60 minutes, your supervisor will collect this question paper and answer sheet before giving out Section 2.

This paper contains **two** parts, **A** and **B**, and you should attempt **both** parts.

Part A Mathematics and Physics (20 questions)
Part B Advanced Mathematics and Advanced Physics (20 questions)

This paper contains 40 multiple-choice questions. There are no penalties for incorrect responses, only marks for correct answers, so you should attempt **all** 40 questions. Each question is worth one mark.

For each question, choose the **one** option you consider correct and record your choice on the separate answer sheet. If you make a mistake, erase thoroughly and try again.

You **must** complete the answer sheet within the time limit.

You can use the question paper for rough working, but **no extra paper** is allowed. Only your responses on the answer sheet will be marked.

Dictionaries and calculators are NOT permitted.

Please wait to be told you may begin before turning this page.

This question paper consists of 30 printed pages and 2 blank pages.

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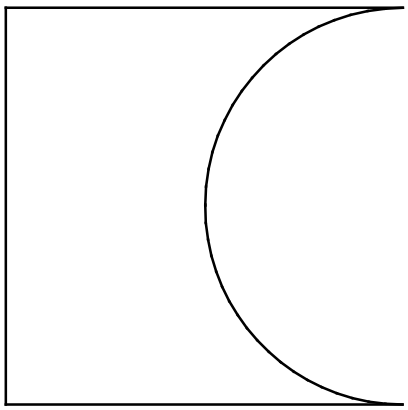
PART A Mathematics and Physics

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 $20\sqrt{\dfrac{2}{8-\pi}}$

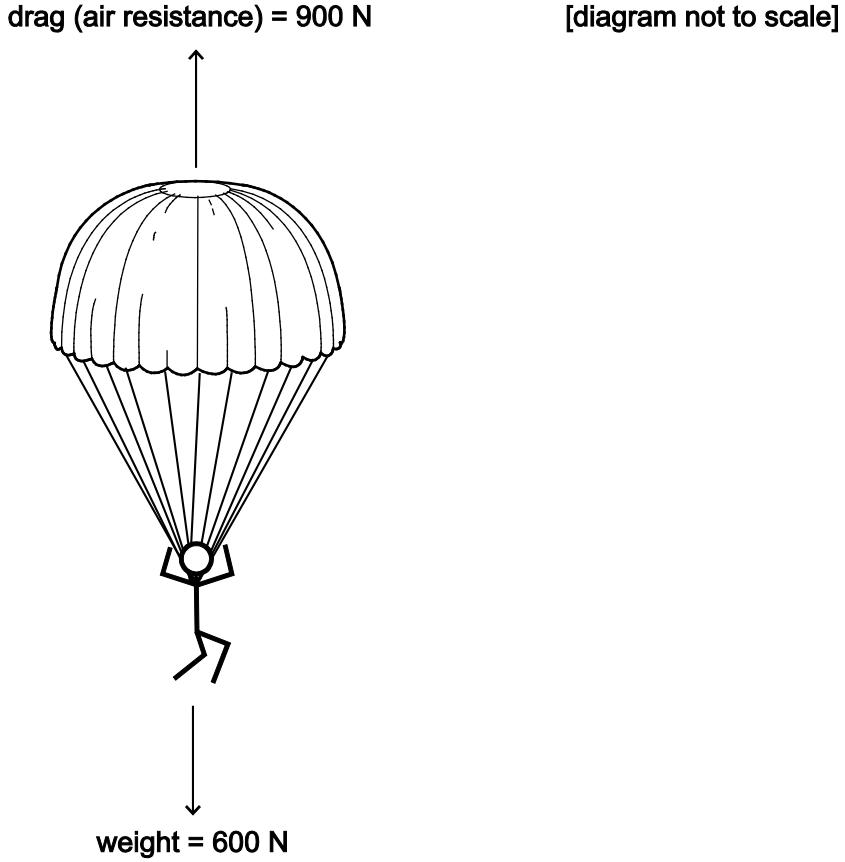
B $10\sqrt{\dfrac{2}{4-\pi}}$

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

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

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

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	—

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°

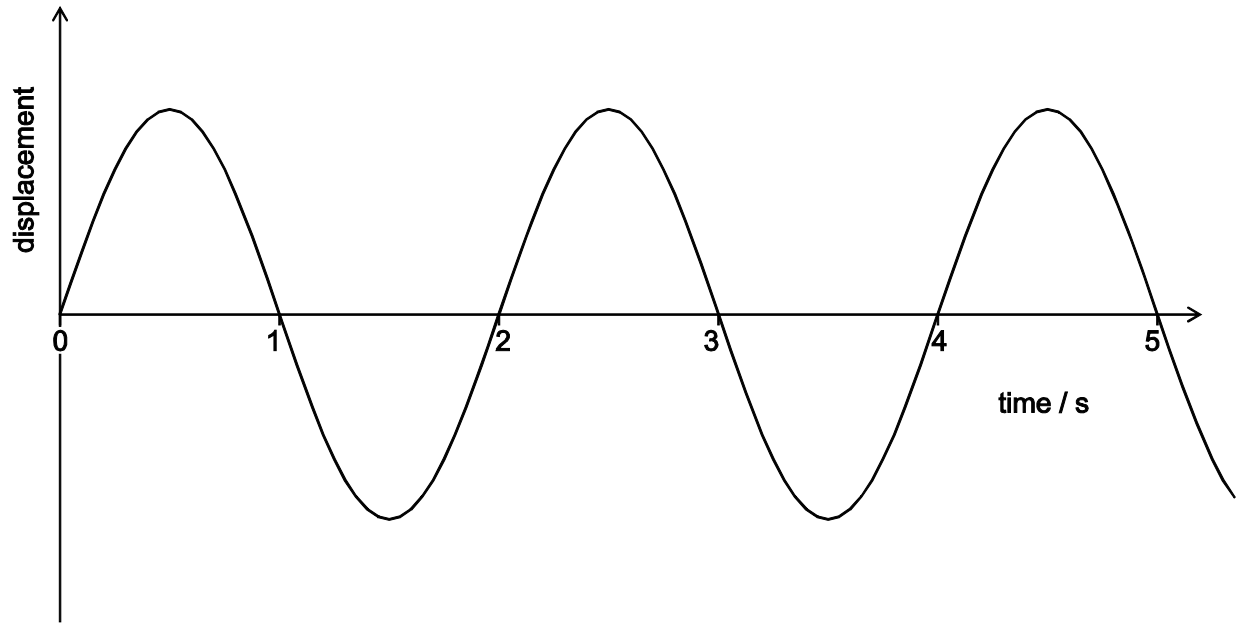
B 7.5°

C 15°

D 22.5°

E 30°

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



What is the speed of the wave?

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

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

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

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

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

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

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 $\sqrt{x}$

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

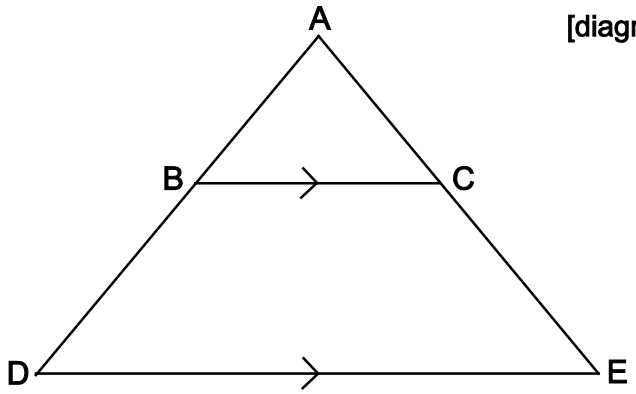
D newton per coulomb

E watt per amp

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

BC is parallel to DE.

AB $= 4\,\text{cm}$ BC $= x\,\text{cm}$ DE $= x + 3\,\text{cm}$ DB $= x - 4\,\text{cm}$



[diagram not to scale]

Calculate the length of DE.

A $5\,\text{cm}$

B $7\,\text{cm}$

C $9\,\text{cm}$

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

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

8 A ball is thrown vertically upwards and leaves the thrower's hand with a speed of $12\,\text{m}\,\text{s}^{-1}$. 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 $= 10\,\text{N}\,\text{kg}^{-1}$)

A $7.2\,\text{m}$

B $14.4\,\text{m}$

C $24\,\text{m}$

D $60\,\text{m}$

E $120\,\text{m}$

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

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 $2vt$

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.

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

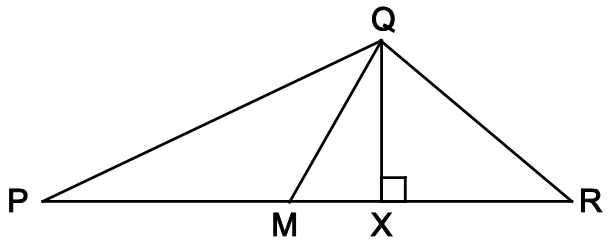
$$ {}^{N}_{R}X \rightarrow {}^{P}_{R-2}Y \rightarrow {}^{P}_{Q}Z $$

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	$R - 4$

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 $\frac{5}{6}$

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

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

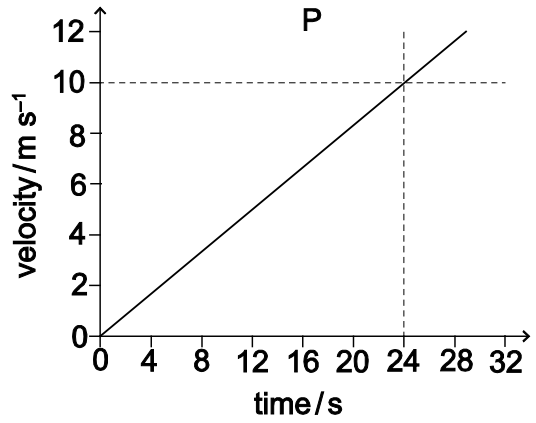
A $x \geq 4$

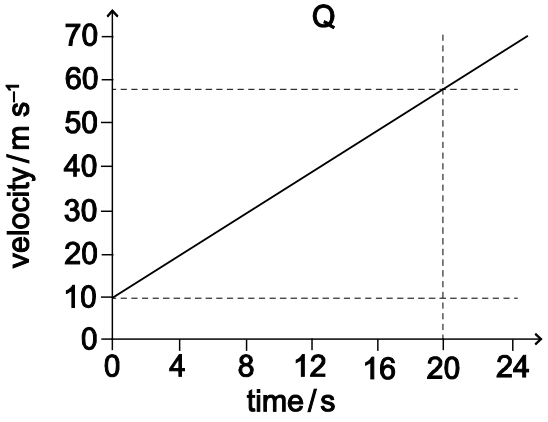
B $x \leq 2$ and $x \geq -4$

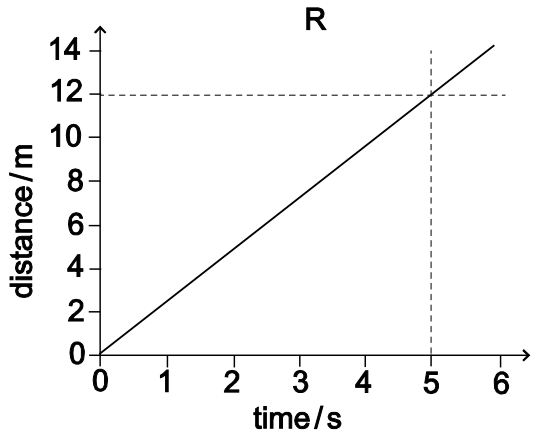
C $x \geq -2$ and $x \leq 4$

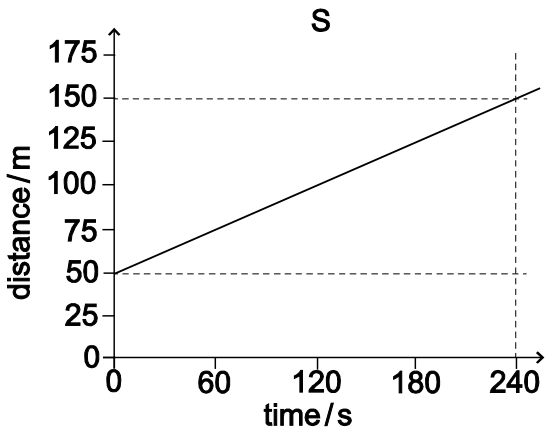
D $x \geq 2$ or $x \leq -4$

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

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 $h = 2r(r-2)$

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

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.

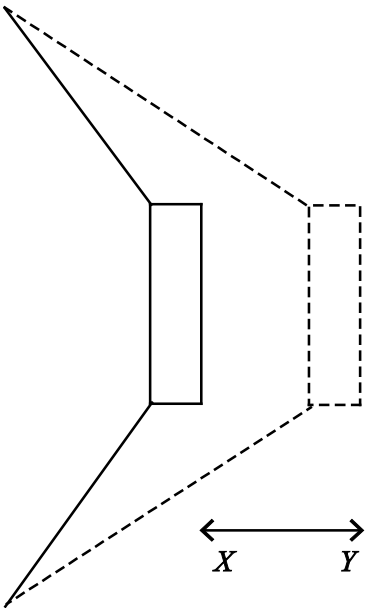
C A reflection in the line $y = -x$.

D A rotation of 90° clockwise about the origin.

E A rotation of 90° anticlockwise about the origin.

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

PART B Advanced Mathematics and Advanced Physics

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

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 $3\,\text{m s}^{-1}$ and particle Q has a speed of $r\,\text{m s}^{-1}$.

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

The speed of P is now $1\,\text{m s}^{-1}$ 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 $\frac{16}{5}$

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

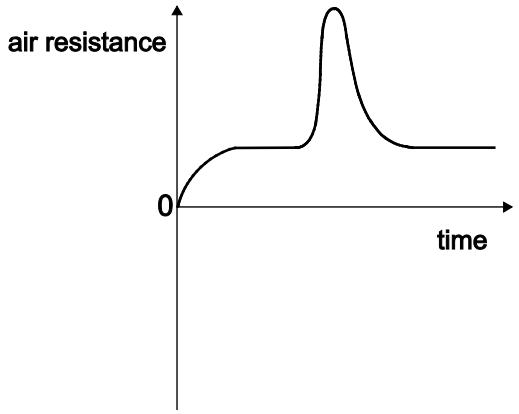
G $\frac{2}{\log_{10}(ab^2c^3)}$

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

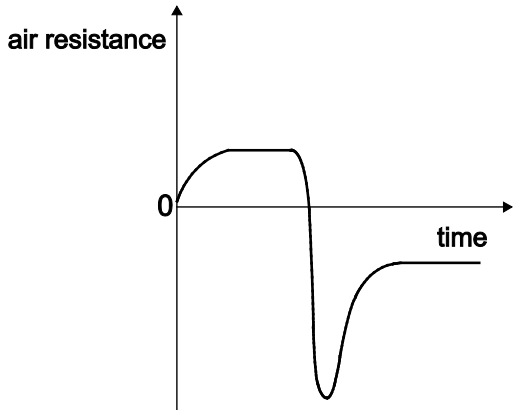
24 A parachutist falls from an aircraft and reaches a terminal velocity. After a while he opens his parachute and reaches a new (lower) terminal velocity.

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

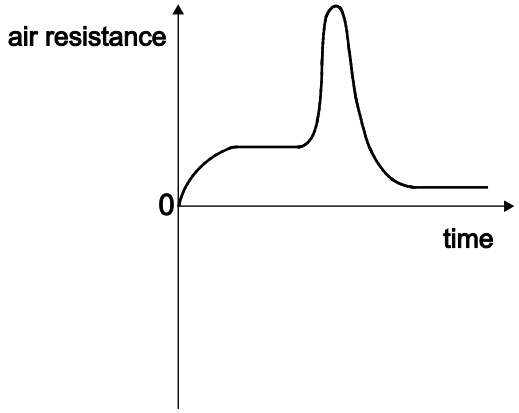
A



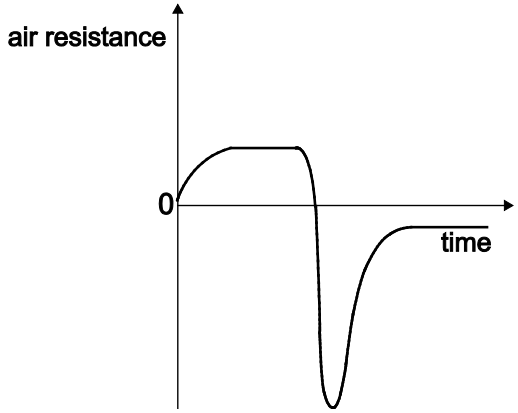
B



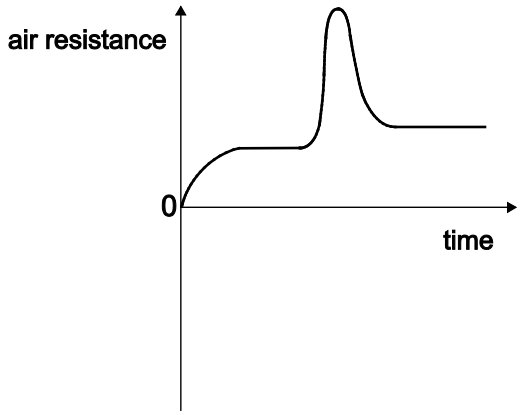
C



D



E



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

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.

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

28 A white billiard ball of mass 0.20 kg is travelling horizontally at $3.0\,\text{m s}^{-1}$ 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 $1.0\,\text{m s}^{-1}$.

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

A $1.0\,\text{m s}^{-1}$

B $1.5\,\text{m s}^{-1}$

C $2.0\,\text{m s}^{-1}$

D $2.5\,\text{m s}^{-1}$

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

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

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

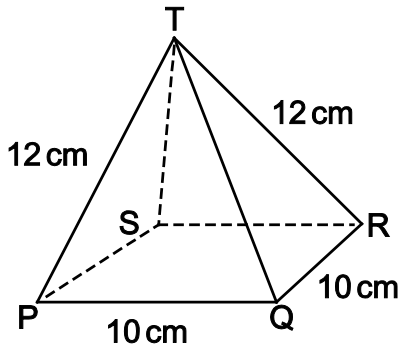
B g_p = 5.0 ; h = 40

C g_p = 10 ; h = 2.0

D g_p = 20 ; h = 1.0

E g_p = 20 ; h = 20

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

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.

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 $y^x = a^b$

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

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

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

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

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

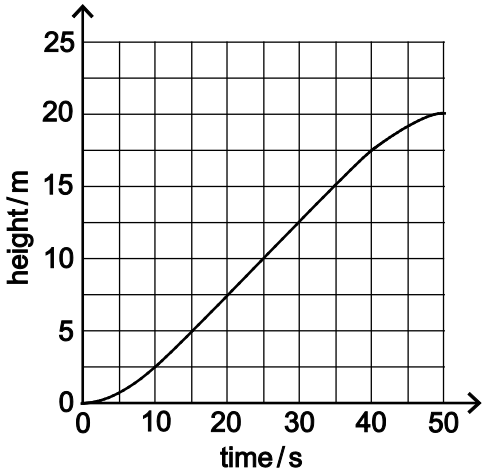
C $2\sqrt{5} - \frac{1}{2}$

D $2\sqrt{5}$

E $2\sqrt{3}$

F $\sqrt{6}$

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

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

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

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

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

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

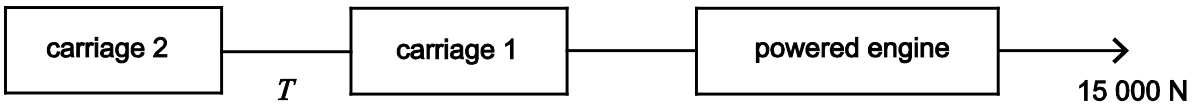
D $\frac{\pi}{3}$

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

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

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

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

END OF TEST

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