

ENGINEERING ADMISSIONS ASSESSMENT

SPECIMEN PAPER

80 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. 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 (28 questions)
Part B	Advanced Mathematics and Advanced Physics (26 questions)

This paper contains 54 multiple choice questions. There are no penalties for incorrect responses, only marks for correct answers, so you should attempt all 54 questions. Each question is worth one mark.

Questions ask you to show your choice between options. 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.

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.

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 may NOT be used.

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

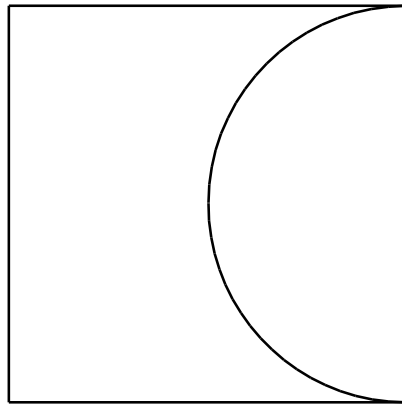
This paper consists of 33 printed pages and 5 blank pages

PV1

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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 cm^2 .



[diagram not to scale]

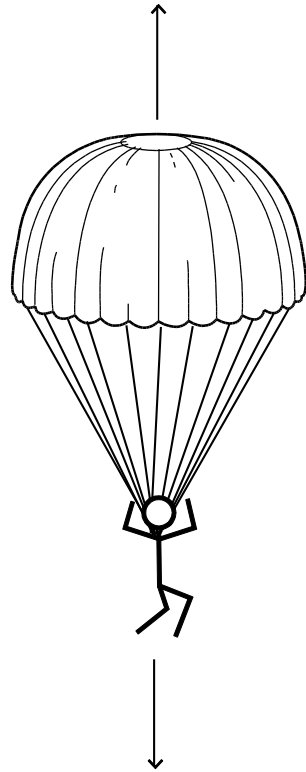
Which one of the following is a correct expression for the length of the side of the square in centimetres?

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

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

drag (air resistance) = 900 N

[diagram not to scale]



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

	<i>size of acceleration / m s⁻²</i>	<i>direction of acceleration</i>
A	5.0	downwards
B	10.0	downwards
C	5.0	upwards
D	10.0	upwards
E	0.0	—

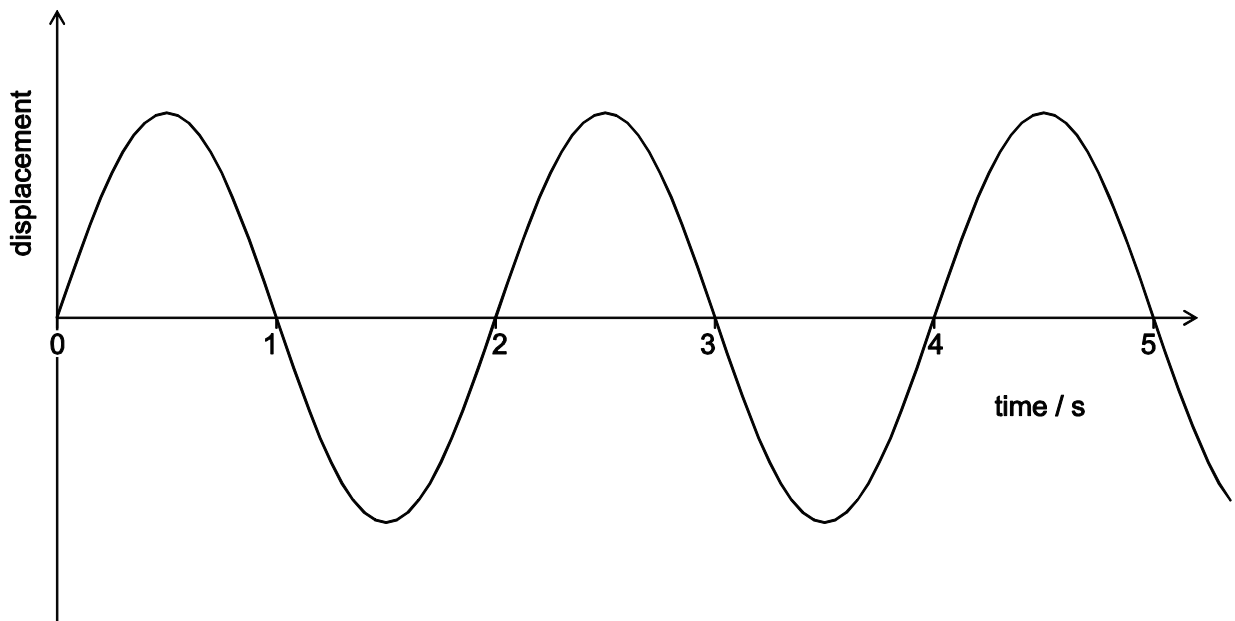
- 3 In a right-angled triangle PQR the hypotenuse is the side PR.

The length of side PQ is 20 cm and the ratio RQ:PQ is 1:2

What is the length of the perpendicular from the hypotenuse to the point Q?

- A $8\sqrt{5}$ cm
- B $10\sqrt{2}$ cm
- C $2\sqrt{5}$ cm
- D $5\sqrt{2}$ cm
- E $4\sqrt{5}$ cm

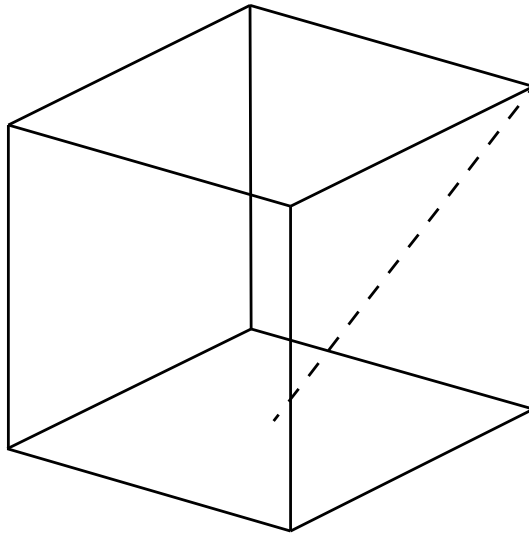
- 4 The displacement/time graph shown represents a wave of wavelength 1.5 cm.



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 A cube has sides of unit length. What is the length of a line joining a vertex to the midpoint of one of the opposite faces (the dashed line in the diagram below)?



[diagram not to scale]

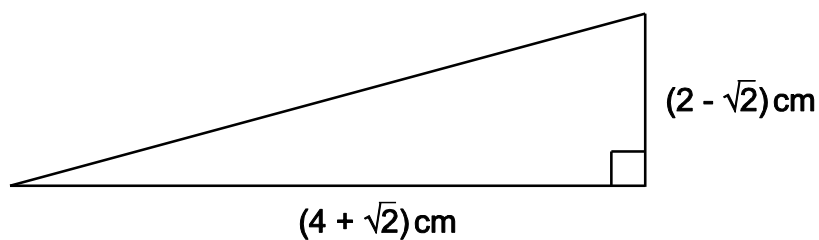
- A $\sqrt{\frac{3}{2}}$
- B $\sqrt{2}$
- C $\sqrt{\frac{5}{2}}$
- D $\sqrt{3}$
- E $\sqrt{5}$
- 6 A point mass travelling at a constant speed has a momentum of 30 N s and a kinetic energy of 150 J.
- What is the mass of the object?
- A 2 kg
- B 3 kg
- C 5 kg
- D 6 kg
- E 10 kg
- F 15 kg

- 7 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°

- 8 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

- 9 The right-angled triangle shown has horizontal and vertical sides measuring $(4 + \sqrt{2})$ cm and $(2 - \sqrt{2})$ cm respectively.



[diagram not to scale]

Calculate the area of the triangle.

- A $(5 + 3\sqrt{2})$ cm²
- B $(3 - \sqrt{2})$ cm²
- C $(3 + 3\sqrt{2})$ cm²
- D $(5 - \sqrt{2})$ cm²

- 10** Two radioactive sources X and Y have half-lives of 4.8 hours and 8.0 hours respectively. Both decay directly to form only stable isotopes.

The activity of a sample of the source X is 320 Bq, and the activity of a sample of the source Y is 480 Bq. The two samples are now combined.

What is the activity of the combination of X and Y 24 hours later?

(An activity of 1 Bq is 1 decay per second.)

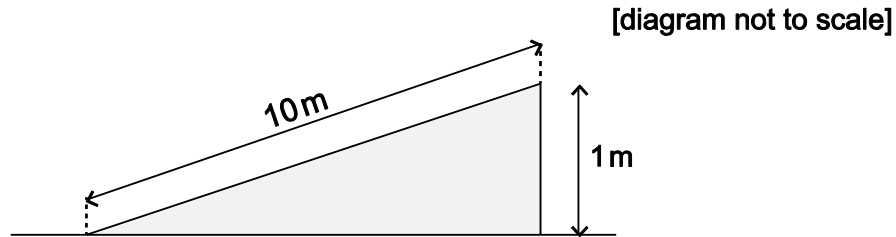
- A 25 Bq
 - B 50 Bq
 - C 55 Bq
 - D 70 Bq
 - E 100 Bq
 - F 140 Bq
- 11** A solid sphere of radius r fits inside a hollow cylinder. The cylinder has the same internal diameter and length as the diameter of the sphere.

The volume of a sphere is $\frac{4}{3} \pi r^3$, where r is the radius of the sphere.

What fraction of the space inside the cylinder is taken up by the sphere?

- A $\frac{1}{4}$
- B $\frac{1}{3}$
- C $\frac{1}{2}$
- D $\frac{2}{3}$
- E $\frac{3}{4}$

- 12 A cyclist and a bike have a combined mass of 100 kg. The cyclist free-wheels (rolls without pedalling) at a constant speed of 0.80 m s^{-1} down a slope where the cyclist descends 1.0 m for each 10 m travelled along the road, as shown in the diagram.



Calculate the loss in gravitational potential energy as the cyclist loses 100 m in vertical height and hence calculate the total resistive force on the cyclist and bike.

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

	<i>loss in gravitational potential energy/J</i>	<i>resistive force/N</i>
A	3200	$32/\sqrt{101}$
B	3200	3.2
C	3200	$32/\sqrt{99}$
D	100 000	$1000/\sqrt{101}$
E	100 000	100
F	100 000	$1000/\sqrt{99}$

- 13 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}

- 14 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.

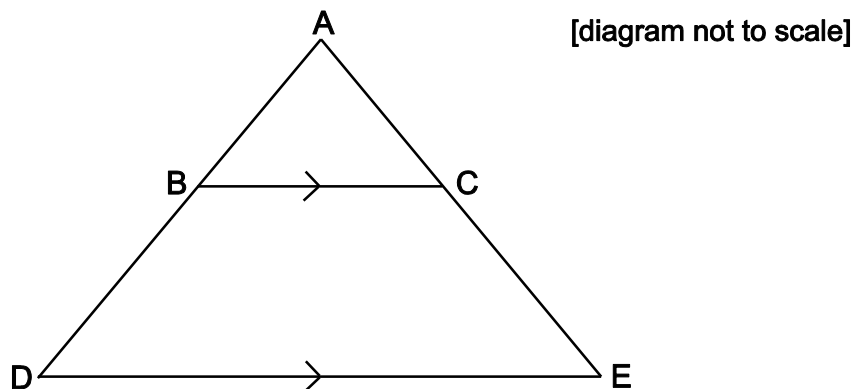
What is the height above the thrower's hand to which it rises?

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

- A 7.2 m
 B 14.4 m
 C 24 m
 D 60 m
 E 120 m
- 15 A shape is formed by drawing a triangle ABC inside the triangle ADE.

BC is parallel to DE.

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



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

- 16 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 = 10 N kg^{-1})

- A $\frac{F}{mg}$
- B $\frac{mgv}{F}$
- C $\frac{mv^2}{2F}$
- D $\frac{v^2}{2g}$
- E vt
- F $2vt$

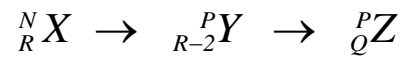
- 17 Two variables are connected by the relation: $P \propto \frac{1}{Q^2}$

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

- 18 Nuclide ${}^N_R X$ is an unstable isotope which decays in two stages into nuclide Z as shown:



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	$R - 4$

- 19 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 ?

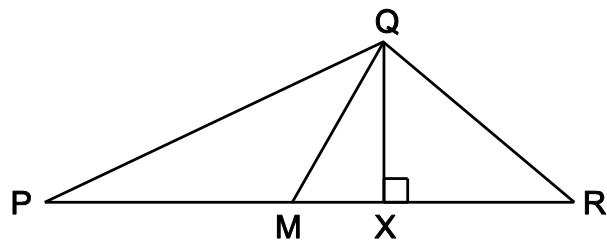
- A The square of x is directly proportional to the cube of y .
- B The square of x is inversely proportional to the cube of y .
- C The cube of x is directly proportional to the square of y .
- D The cube of x is inversely proportional to the square of y .
- E x is directly proportional to y^6 .

- 20** 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

21 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 $\frac{1}{9}$

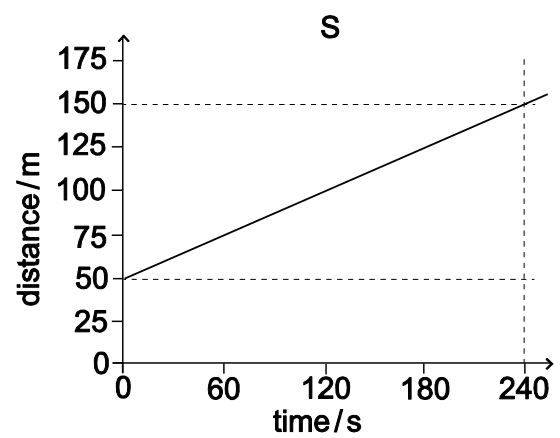
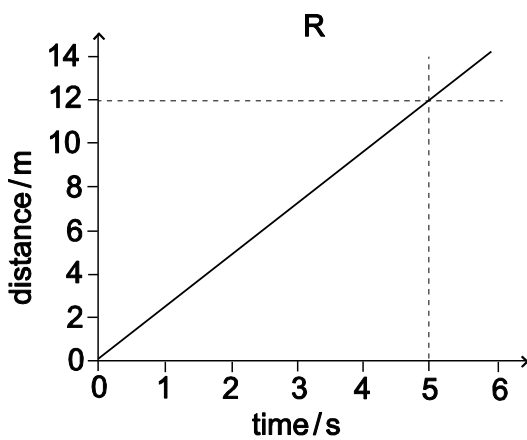
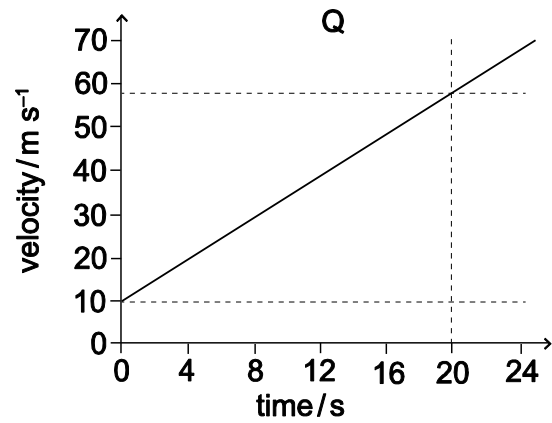
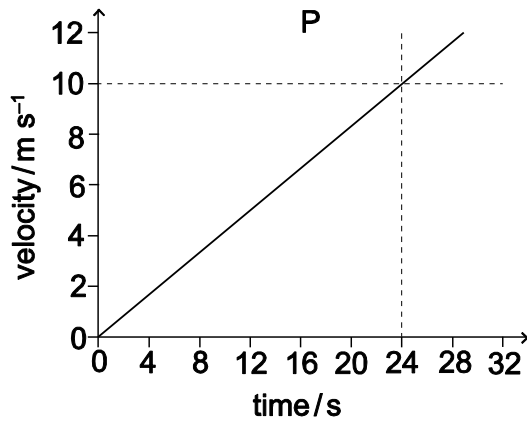
B $\frac{5}{12}$

C $\frac{4}{9}$

D $\frac{1}{2}$

E $\frac{5}{6}$

- 22 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

23 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 $x \leq -4$

24 Which one of the following statements about nuclear physics is true?

- A The process of emission of a gamma ray from a nucleus is called nuclear fission.
- B The half-life of a radioactive substance is half the time taken for its nuclei to decay.
- C The number of neutrons in a nucleus is its atomic number (proton number) minus its mass number.
- D When a nucleus emits a beta particle, there is no change in the number of particles it contains.
- E When a nucleus emits an alpha particle, one of its neutrons becomes a proton plus an electron.

25 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 $h = \frac{2r}{r-2}$
- B $h = \frac{2r}{r+2}$
- C $h = r+2$
- D $h = r-2$
- E $h = 2r(r-2)$

- 26** 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 $\frac{VR_1}{R_1 + R_2}$

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

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

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

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

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

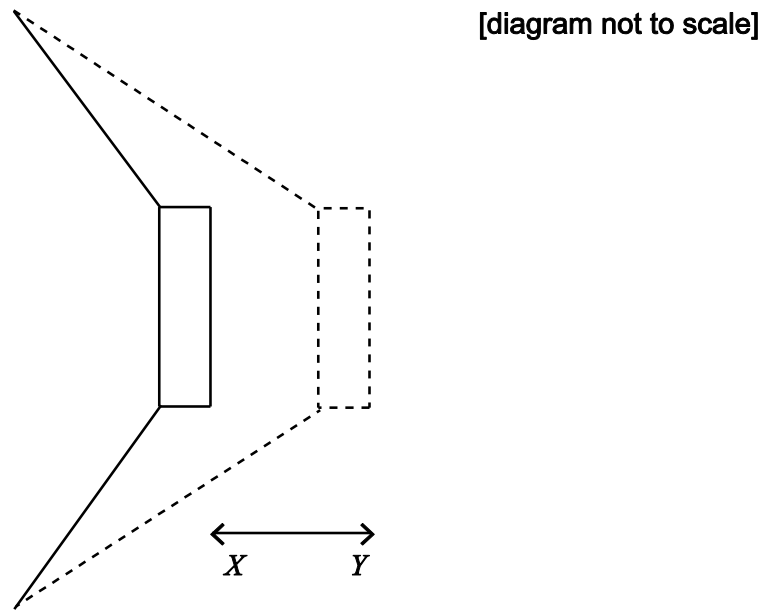
- 27** The square PQRS is positioned so that its vertices are at the points with coordinates: $(1, 1)$, $(-1, 1)$, $(-1, -1)$ and $(1, -1)$.

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.

- 28** 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.



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 E Advanced Mathematics and Advanced Physics

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

30 A car and driver, of total mass 1000 kg, travel with uniform acceleration from rest along a horizontal road. The car's engine produces a force of 3.0 kN. After a time of 5.0 s the car reaches a speed of 10 m s^{-1} . Consider the resistive forces acting on the car to be constant.

What is the acceleration of the car $a \text{ m s}^{-2}$ and what is the total of the resistive forces $f \text{ kN}$ acting on the car?

A $a = 2.0; f = 1.0$

B $a = 2.0; f = 2.0$

C $a = 2.0; f = 3.0$

D $a = 3.0; f = 1.0$

E $a = 3.0; f = 2.0$

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

32 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 $r \text{ m s}^{-1}$.

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

The speed of P is now 1 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 $\frac{16}{5}$

33 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 $\log_{10} 100$

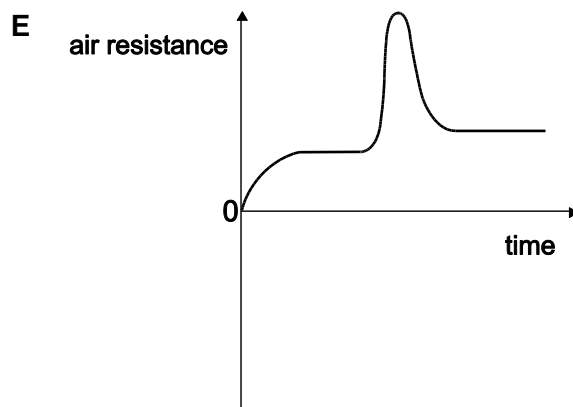
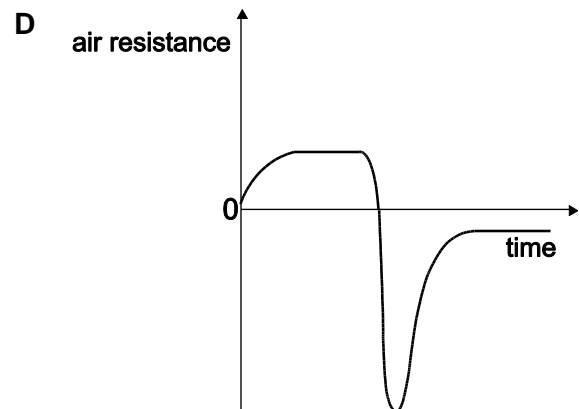
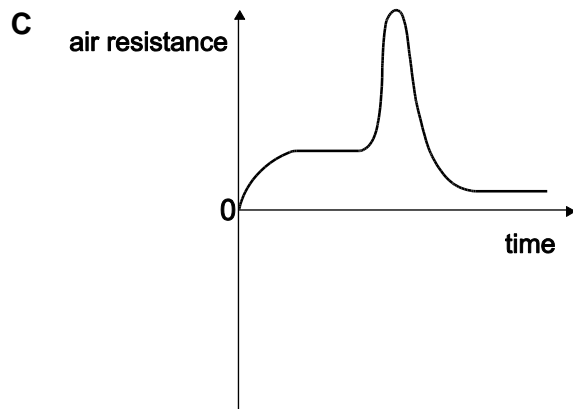
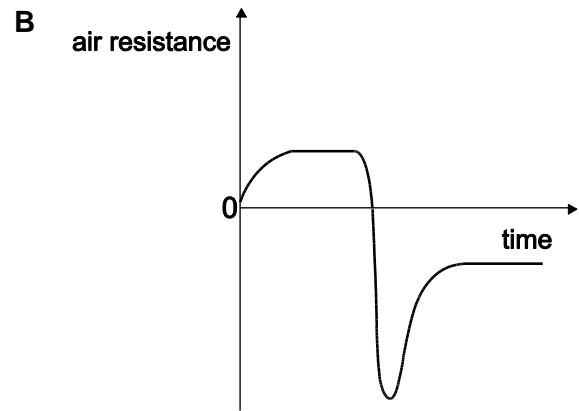
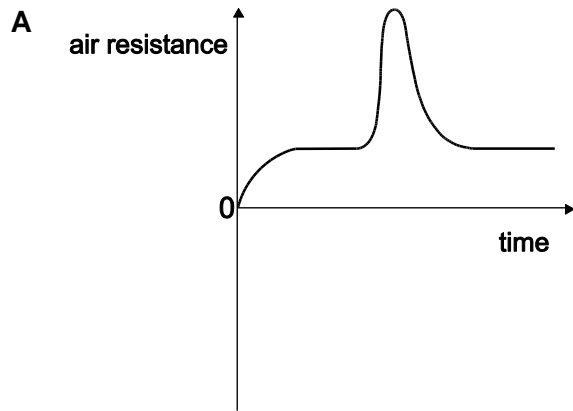
C $\sin^{10}\left(\frac{\pi}{2}\right)$

D $\log_2 10$

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

- 34 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?

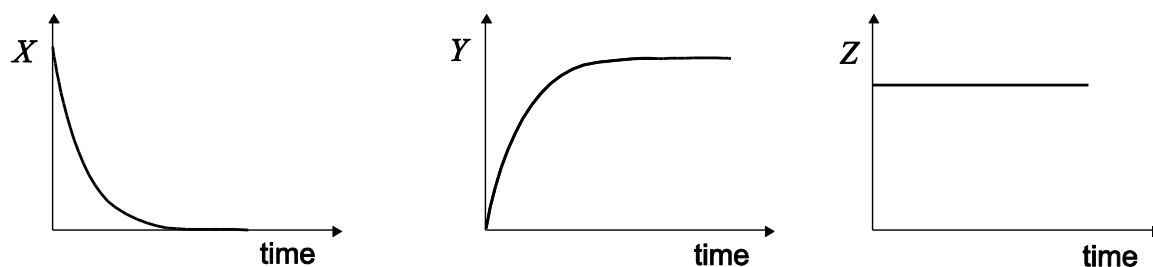


35 The sum of the roots of the equation $2^{2x} - 8 \times 2^x + 15 = 0$ is

- A 3
 B 8
 C $2\log_{10} 2$
 D $\log_{10} \left(\frac{15}{4} \right)$
 E $\frac{\log_{10} 15}{\log_{10} 2}$

36 A car is accelerated from rest along a horizontal road by a constant thrust force produced by the engine. The car eventually reaches a terminal velocity.

The graphs below show the variation with time of three quantities (X , Y and Z) for the car:



Which line in the table could correctly identify the quantities X , Y and Z ?

	X	Y	Z
A	acceleration	air resistance (drag force)	kinetic energy
B	acceleration	mass of car	weight of car
C	(gravitational) potential energy	velocity	kinetic energy
D	(gravitational) potential energy	air resistance (drag force)	weight of car
E	resultant force	mass of car	kinetic energy
F	resultant force	velocity	weight of car

37 For any real numbers a , b , and c where $a \geq b$, consider these three statements:

1 $-b \geq -a$

2 $a^2 + b^2 \geq 2ab$

3 $ac \geq bc$

Which of the above statements must be true?

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

38 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.

- 39 The sequence a_n is given by the rule:

$$a_1 = 2$$
$$a_{n+1} = a_n + (-1)^n \text{ for } n \geq 1$$

What is

$$\sum_{n=1}^{100} a_n$$

- A 150
- B 250
- C -4750
- D 5150
- E $4 \left(1 - \left(\frac{1}{2} \right)^{100} \right)$
- F $4 \left(\left(\frac{3}{2} \right)^{100} - 1 \right)$
- 40 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}

41 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

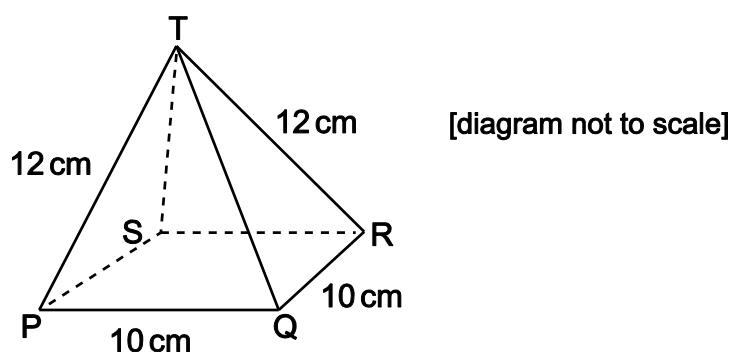
42 A certain planet has no atmosphere. The planet has a gravitational field strength at its surface of $g_p \text{ N kg}^{-1}$; this value is considered constant for this question. A rock is projected vertically upwards from the surface of the planet at an initial speed of 20 m s^{-1} . The rock reaches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

- 43 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.



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 $\cos^{-1} \frac{5\sqrt{2}}{12}$
- 44 A ball is dropped from a height of 16 m on to a horizontal surface, and on each bounce loses 50% of its kinetic energy.
- After which bounce will the maximum height of the rebound fall to less than 160 cm for the first time?
- (Assume air resistance is negligible, and the only external force acting on the ball while not in contact with the surface is gravity.)
- A 4th
- B 5th
- C 6th
- D 7th
- E 8th

- 45 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 $y^x = a^b$

- 46 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.

- 47 For what values of the non-zero real number a does the quadratic equation

$$ax^2 + (a - 2)x = 2$$

have distinct real roots?

A all values of a

B $a = -2$

C $a > -2$

D $a \neq -2$

E no values of a

- 48** 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

- 49** 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

- 50** 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** $1.25\sqrt{3} \text{ N}$
- B** 5 N
- C** $5\sqrt{3} \text{ N}$
- D** 10 N
- E** $10\sqrt{3} \text{ N}$

51 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 $2\sqrt{3} - \frac{1}{2}$

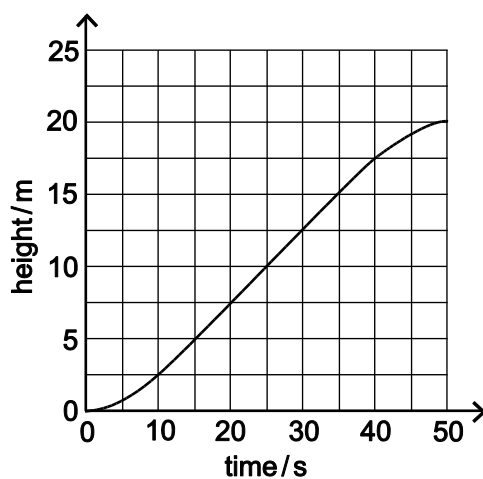
C $2\sqrt{5} - \frac{1}{2}$

D $2\sqrt{5}$

E $2\sqrt{3}$

F $\sqrt{6}$

- 52 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)

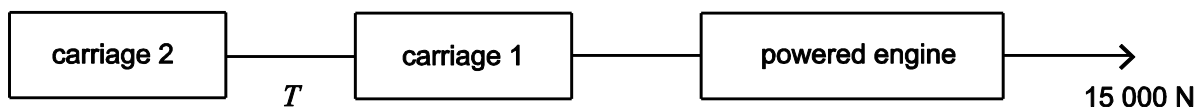
- A 0.1 W
- B 10 W
- C 40 W
- D 100 W
- E 400 W
- F 4000 W

- 53 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 $\frac{5\pi}{6}$

- 54 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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