

ENGINEERING  
ADMISSIONS ASSESSMENT

D564/12

2022

60 minutes

## SECTION 2

## 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 2 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.

This paper contains 20 multiple-choice questions. There are no penalties for incorrect responses, only marks for correct answers, so you should attempt **all** 20 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.

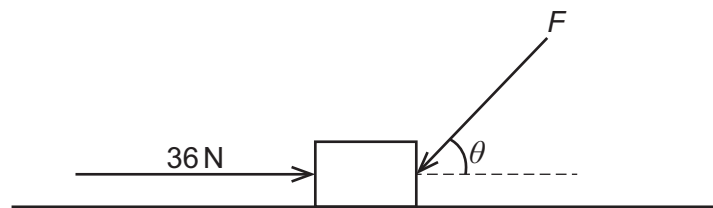
**Please wait to be told you may begin before turning this page.**

*This question paper consists of 22 printed pages and 2 blank pages.*



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- 1 The diagram shows an object of mass 2.4 kg on a smooth horizontal surface.



A force  $F$  acts on the object at an acute angle  $\theta$  to the horizontal, where  $\tan \theta = \frac{4}{3}$ .

A force of 36 N acts on the object towards the right.

The object is in equilibrium.

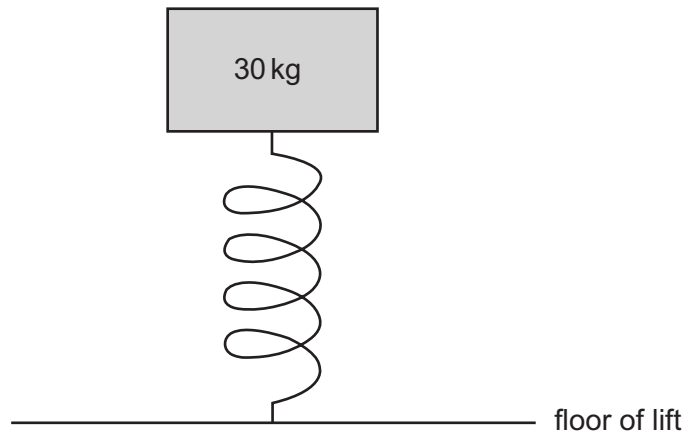
What is the magnitude of the normal contact force exerted on the object by the surface?

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

- A 24 N
- B 27 N
- C 48 N
- D 51 N
- E 72 N
- F 75 N

- 2** The length of a spring when no force acts on it is  $L$ . The spring constant of the spring is  $3.0 \times 10^3 \text{ N m}^{-1}$ .

The spring is on the floor of an accelerating lift (elevator), and the spring supports a 30 kg mass.



The lift is accelerating downwards at  $2.0 \text{ m s}^{-2}$ .

What is the difference between  $L$  and the length of the spring when the lift is accelerating downwards?

(gravitational field strength =  $10 \text{ N kg}^{-1}$ ; the spring obeys Hooke's law)

- A** 0 cm
- B** 2.0 cm
- C** 8.0 cm
- D** 10 cm
- E** 12 cm

- 3** Electrical energy is transmitted at high voltage to a remote farm using an overhead power cable. Each of the two wires in the cable has a resistance of  $2.5\ \Omega$ . The step-down transformer in the farm has a voltage ratio of 5.0. The transformer is ideal and 100% efficient. It supplies a power of 40 kW to a resistive load at the farm at a voltage of 250 V.

What is the rate at which electrical energy is transferred to thermal energy in the overhead cable?

- A** 1.28 kW
- B** 2.56 kW
- C** 5.12 kW
- D** 32 kW
- E** 64 kW
- F** 128 kW

- 4** A wave is passing through a medium.

A particle of the medium has zero displacement from its equilibrium position at 0.12 s intervals, and at no other times.

The wavelength of the wave is greater than 10.0 m.

Two points are 5.0 m apart along the direction of travel of the wave.

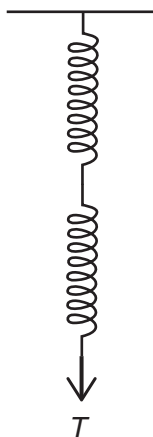
The phase difference between the particles at the two points at the same instant is  $\frac{\pi}{3}$  radians.

What is the speed of the wave?

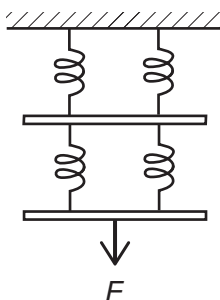
- A**  $1.8 \text{ m s}^{-1}$
- B**  $3.6 \text{ m s}^{-1}$
- C**  $7.2 \text{ m s}^{-1}$
- D**  $62.5 \text{ m s}^{-1}$
- E**  $125 \text{ m s}^{-1}$
- F**  $250 \text{ m s}^{-1}$

- 5 Three light springs, P, Q and R, are identical.

Springs P and Q are connected in series as shown. A downwards force  $T$  is applied to the lower end.



Spring R is cut into four equal lengths, and the four pieces arranged symmetrically as shown. The two connecting bars have negligible mass. A downwards force  $F$  is applied to the centre of the lower bar.



The total extensions of the two systems are equal. The springs obey Hooke's law.

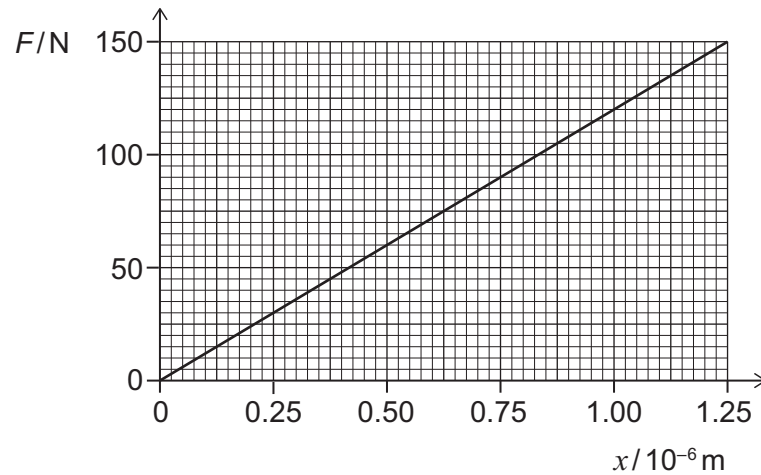
Which expression gives  $T$  in terms of  $F$ ?

- A  $\frac{F}{16}$
- B  $\frac{F}{8}$
- C  $\frac{F}{4}$
- D  $\frac{F}{2}$
- E  $2F$
- F  $4F$
- G  $8F$
- H  $16F$

- 6 A nylon cube resting on a horizontal surface has a volume of  $64 \text{ cm}^3$ .

A force  $F$  is applied vertically downwards on the top face of the cube so that it compresses the height by  $x$ .

The graph shows the variation of  $F$  with  $x$ .



What is the Young modulus of the nylon?

(Assume that changes in horizontal cross-sectional area are negligible.)

- A  $7.7 \times 10^3 \text{ Pa}$
- B  $4.8 \times 10^6 \text{ Pa}$
- C  $9.6 \times 10^6 \text{ Pa}$
- D  $1.2 \times 10^8 \text{ Pa}$
- E  $1.5 \times 10^9 \text{ Pa}$
- F  $3.0 \times 10^9 \text{ Pa}$
- G  $1.9 \times 10^{12} \text{ Pa}$



- 7 Five lampposts alongside a straight road are positioned at uniform intervals of 60 m.

A motorbike travelling at a constant velocity passes the first lamppost at time  $t = 0$  s. It passes the fifth lamppost at  $t = 20$  s.

A car travelling in the same direction as the motorbike is accelerating at  $6.0 \text{ m s}^{-2}$ . At time  $t = 0$  s the car passes the first lamppost at a velocity of  $3.0 \text{ m s}^{-1}$ .

At what time  $t$  does the car overtake the motorbike?

- A 1.5 s
- B 2.0 s
- C 2.5 s
- D 3.0 s
- E 3.5 s
- F 4.0 s
- G 5.0 s

- 8 An electrical appliance has an input power  $P$  which is a function of time  $t$  during the first 10 seconds after it is switched on.

This function is

$$P = 3t^2 + 4t$$

where  $P$  is in watts and  $t$  is in seconds.

The appliance is switched on at time  $t = 0$ .

The appliance has a constant efficiency of 90%.

What is the energy **wasted** by the appliance during the period  $t = 2.0\text{s}$  to  $t = 3.0\text{s}$  after it is switched on?

- A 0.60J
- B 0.70J
- C 1.9J
- D 2.9J
- E 4.5J
- F 17J
- G 26J
- H 41J

- 9** A solid cylinder is made of transparent glass of refractive index  $\frac{2}{\sqrt{3}}$ . It is surrounded by air.

A ray of light travelling in air hits the cylinder at the centre of one circular face at a non-zero angle  $\theta$  to the normal, and refracts as it enters the cylinder.

The ray then strikes the curved surface of the cylinder at an angle of incidence equal to the critical angle.

What is the value of  $\theta$ ?

**A**  $\sin^{-1} \frac{\sqrt{3}}{4}$

**B**  $\sin^{-1} \frac{1}{\sqrt{3}}$

**C**  $\sin^{-1} \frac{2}{\sqrt{6}}$

**D**  $\sin^{-1} \frac{\sqrt{3}}{2}$

**E**  $\sin^{-1} 1$

- 10** An object of mass 20 kg is acted on by a force that varies in magnitude during the time interval  $t = 0$  s to  $t = 1.0$  s.

The force causes the object's displacement  $x$  to change with time  $t$  according to the relationship

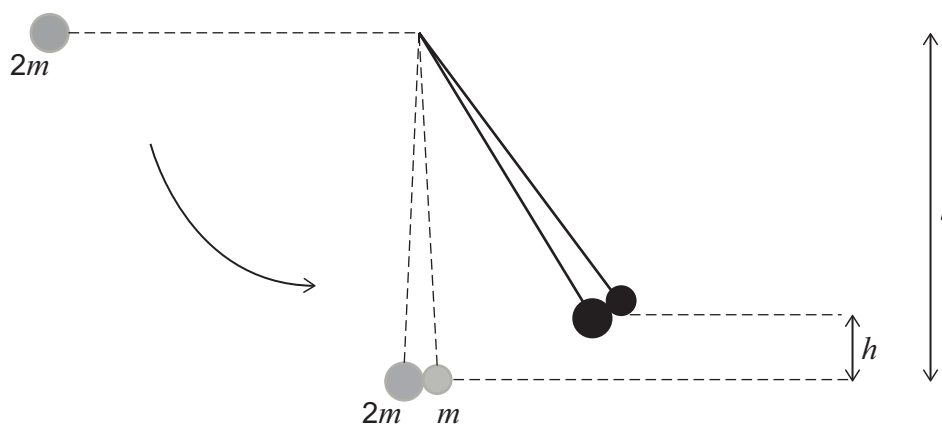
$$x = -t^3 - 3t^2 + 4$$

where  $x$  is in metres and  $t$  is in seconds.

What is the magnitude of the impulse on the object over this time interval?

- A**  $2.8 \text{ kgms}^{-1}$
- B**  $9.0 \text{ kgms}^{-1}$
- C**  $55 \text{ kgms}^{-1}$
- D**  $80 \text{ kgms}^{-1}$
- E**  $100 \text{ kgms}^{-1}$
- F**  $180 \text{ kgms}^{-1}$

- 11 Two small hard spheres of mass  $m$  and  $2m$  are suspended side by side from light vertical strings of length  $l$ . The more massive sphere is raised so that its string is horizontal, and then released. It swings through  $90^\circ$  and strikes the smaller sphere. The two spheres stick together, and rise to a maximum height  $h$  as shown in the diagram.



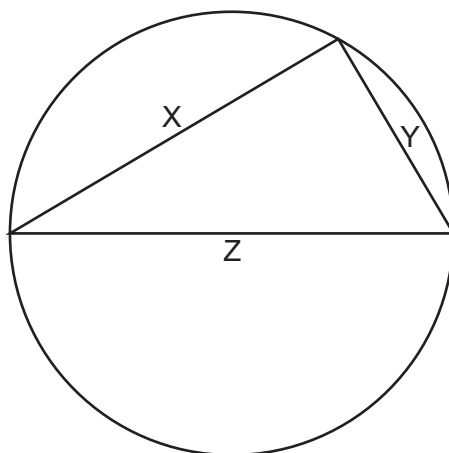
[diagram not to scale]

Which expression gives the height  $h$  in terms of  $l$ ?

(Assume that air resistance is negligible.)

- A  $\frac{4l}{27}$
- B  $\frac{8l}{27}$
- C  $\frac{4l}{9}$
- D  $\frac{2l}{3}$
- E  $\frac{8l}{9}$
- F  $l$
- G  $2l$

- 12 Three resistance wires X, Y and Z, made from the same metal, are connected to each other and to a circular plastic ring as shown.



[diagram not to scale]

Wires X and Y each have twice the diameter of wire Z.

Wire X is 12 cm long. Wire Z is 15 cm long and is connected across a diameter of the ring.

A power supply is connected to the two corners of the triangle that lie on the diameter.

What is the value of the ratio

$$\frac{\text{current in X}}{\text{current in Z}} ?$$

- A  $\frac{1}{5}$
- B  $\frac{7}{20}$
- C  $\frac{7}{10}$
- D  $\frac{5}{7}$
- E  $\frac{7}{5}$
- F  $\frac{10}{7}$
- G  $\frac{20}{7}$
- H 5

- 13** A light rope has cross-sectional area  $6.0 \times 10^{-8} \text{ m}^2$  and unstretched length 0.24 m.

The rope is fixed horizontally between two supports that are 0.24 m apart.

When a 1.0 kg mass is suspended from the middle of the rope, the vertical displacement of the middle of the rope from its original position is 0.050 m.

The rope obeys Hooke's law. Assume that changes in cross-sectional area are negligible.

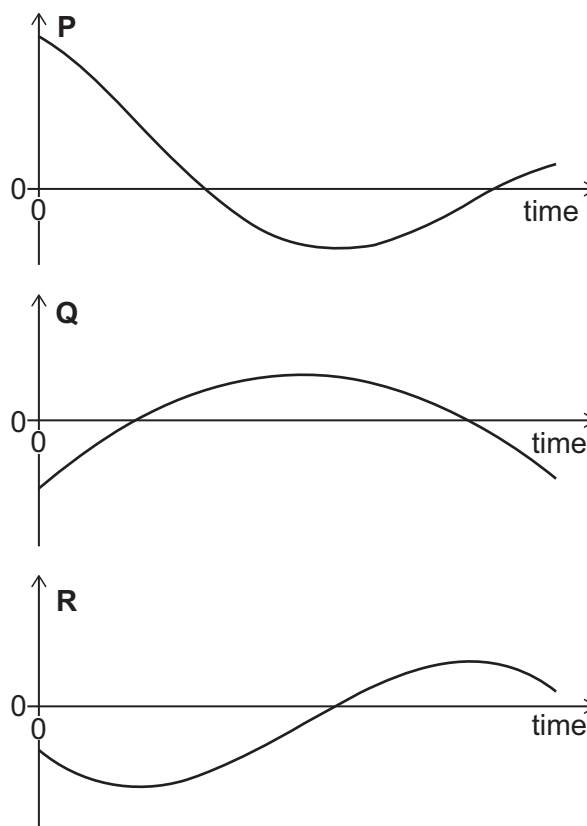
What is the Young modulus of the material from which the rope is made?

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

- A**  $5.2 \times 10^8 \text{ N m}^{-2}$
- B**  $8.0 \times 10^8 \text{ N m}^{-2}$
- C**  $1.0 \times 10^9 \text{ N m}^{-2}$
- D**  $1.3 \times 10^9 \text{ N m}^{-2}$
- E**  $2.0 \times 10^9 \text{ N m}^{-2}$
- F**  $2.6 \times 10^9 \text{ N m}^{-2}$
- G**  $5.2 \times 10^9 \text{ N m}^{-2}$

- 14** The three graphs show the displacement, velocity and acceleration against time for an object moving in a straight line.

The time axis is shown to the same scale on all three graphs.



Which graph represents which quantity?

	<i>graph P</i>	<i>graph Q</i>	<i>graph R</i>
<b>A</b>	acceleration	displacement	velocity
<b>B</b>	acceleration	velocity	displacement
<b>C</b>	displacement	acceleration	velocity
<b>D</b>	displacement	velocity	acceleration
<b>E</b>	velocity	acceleration	displacement
<b>F</b>	velocity	displacement	acceleration



- 15** A system of light springs that does not obey Hooke's law has an unstretched length of 2.0 m. The extension  $x$  of the system is related to the force  $F$  applied to it by

$$F = px^2$$

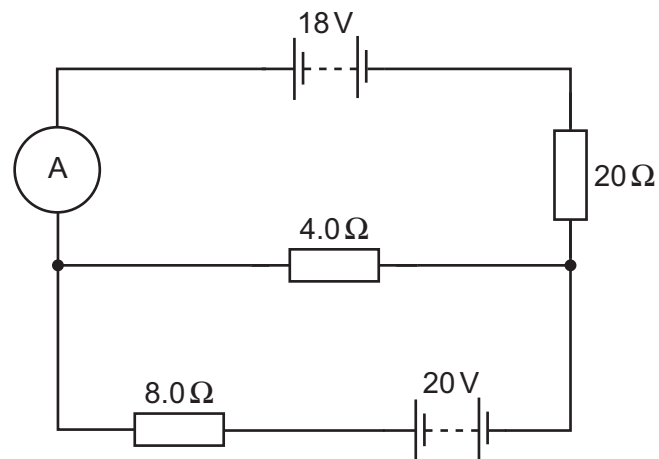
where  $p$  is a constant.

A force of 2400 N increases the length of the system to 2.2 m.

How much work is done in increasing the length of the system from 3.0 m to 4.0 m?

- A** 1.2 kJ
- B** 60 kJ
- C** 70 kJ
- D** 120 kJ
- E** 140 kJ
- F** 740 kJ

- 16 The diagram shows a circuit that includes two batteries, each with negligible internal resistance.

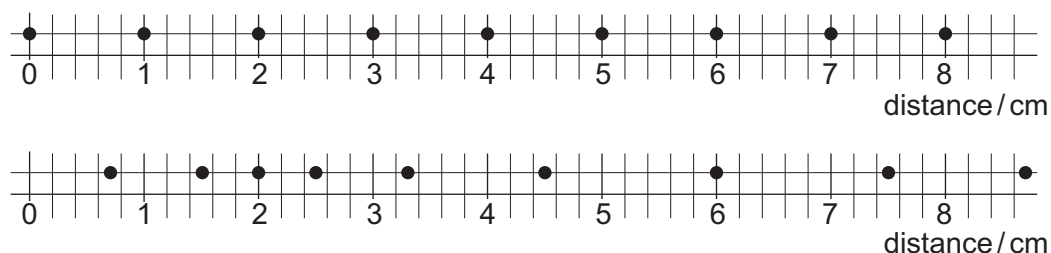


What is the reading on the ammeter?

- A 0.0029 A
- B 0.0071 A
- C 0.063 A
- D 0.083 A
- E 0.50 A
- F 0.65 A
- G 1.2 A
- H 2.0 A

- 17 The upper diagram shows the equilibrium positions of nine equally spaced particles in a medium.

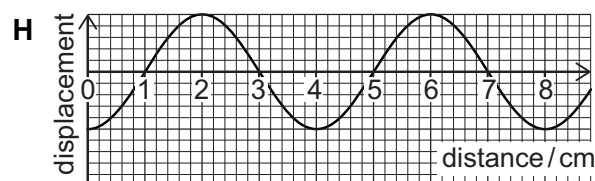
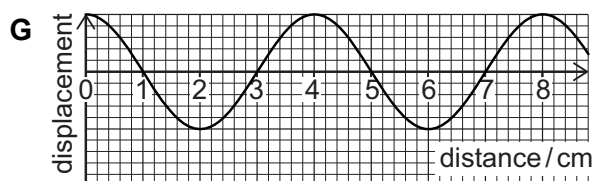
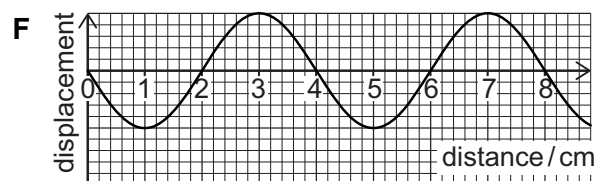
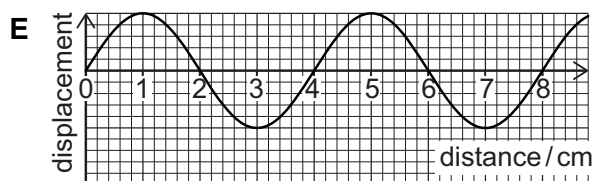
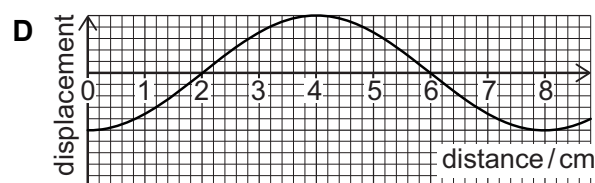
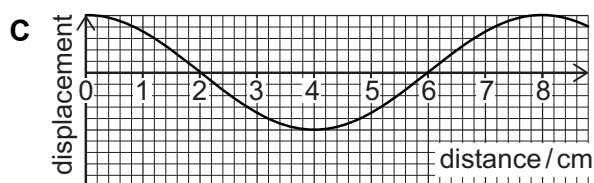
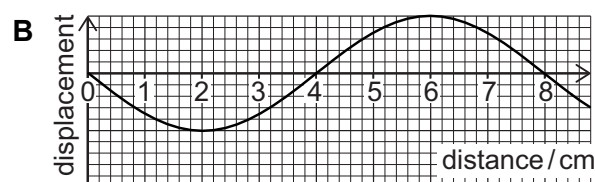
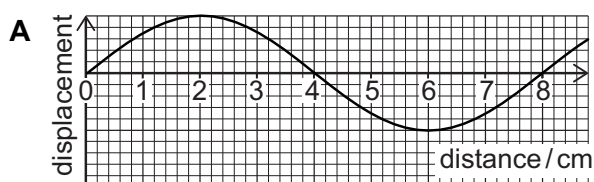
The lower diagram shows the positions of the same nine particles when a longitudinal wave is travelling through the medium. The wave is shown at time  $t = 0$ , travelling to the right.



The frequency of the wave is 0.5 Hz.

Which graph represents the displacements of the particles at a later time  $t = 0.5$  s?

(On the graphs, positive displacement values represent particle displacements to the right.)

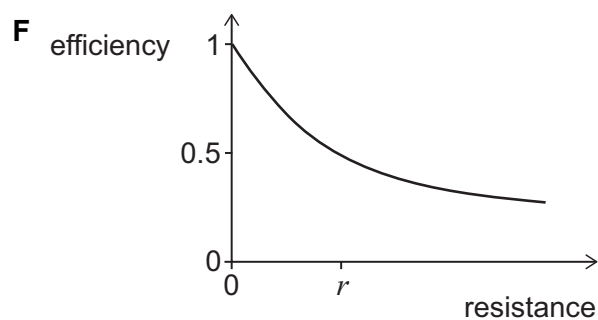
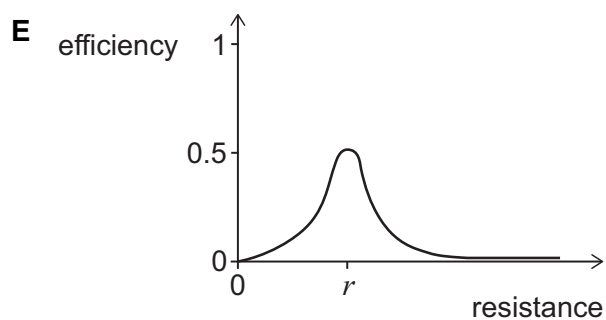
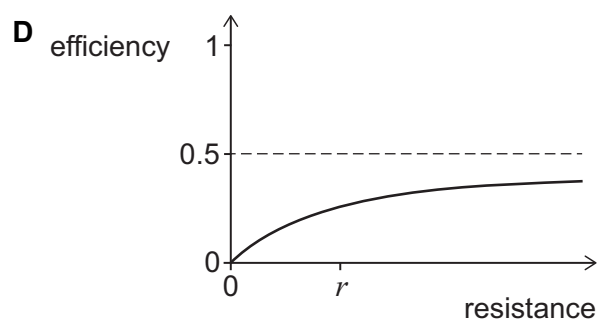
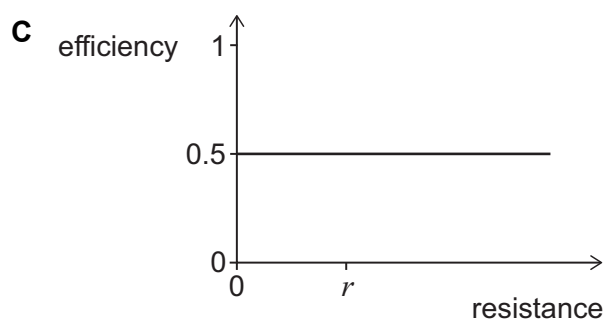
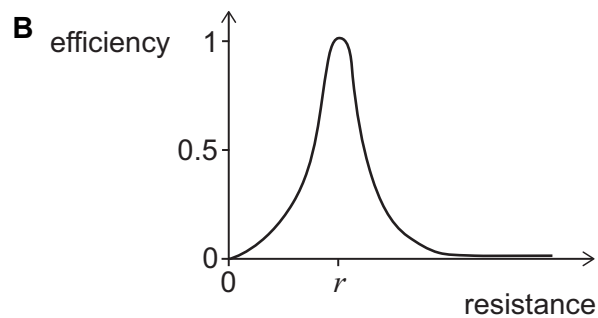
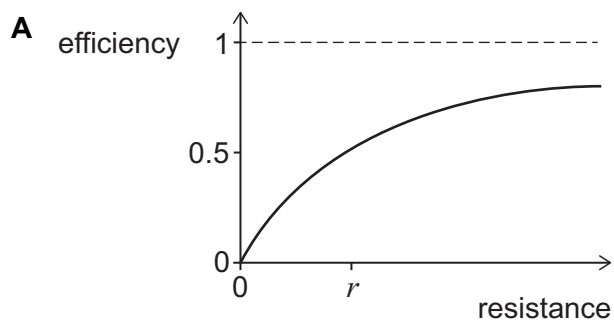


- 18 A power supply with constant emf and internal resistance  $r$  is connected to an external resistor.

The efficiency of the system is defined as

$$\text{efficiency} = \frac{\text{power dissipated by external resistor}}{\text{total power supplied by cell}}$$

Which graph shows how the efficiency varies with the resistance of the external resistor?



- 19** A 10 kg projectile is launched from ground level at an angle of  $60^\circ$  above the horizontal, with an initial speed of  $12 \text{ m s}^{-1}$ . The horizontal component of its velocity is to the right.

At the point during its flight when the vertical component of its velocity is zero, the projectile splits into two pieces, P and Q, each of mass 5 kg.

Immediately after the projectile splits, piece P has velocity  $14 \text{ m s}^{-1}$  to the right.

What is the speed of piece Q immediately before it hits the ground?

(Assume that air resistance is negligible, and that the ground is horizontal.)

- A**  $2 \text{ m s}^{-1}$
- B**  $\sqrt{31} \text{ m s}^{-1}$
- C**  $6\sqrt{3} \text{ m s}^{-1}$
- D**  $4\sqrt{7} \text{ m s}^{-1}$
- E**  $2\sqrt{43} \text{ m s}^{-1}$
- F**  $4\sqrt{13} \text{ m s}^{-1}$
- G**  $4\sqrt{19} \text{ m s}^{-1}$
- H**  $2\sqrt{127} \text{ m s}^{-1}$

- 20** The density  $\rho$  of a sphere varies from its centre to its surface according to the equation

$$\rho = \rho_0 \left( 1 - \frac{x}{2R} \right)$$

where  $x$  is the distance from its centre,  $R$  is its radius and  $\rho_0$  is the density at its centre.

What is the mass of the sphere?

(the surface area of a sphere of radius  $x$  is equal to  $4\pi x^2$ )

- A**  $\frac{2\pi R^3 \rho_0}{3}$
- B**  $\frac{5\pi R^3 \rho_0}{6}$
- C**  $\frac{8\pi R^3 \rho_0}{9}$
- D**  $\pi R^3 \rho_0$
- E**  $\frac{29\pi R^3 \rho_0}{24}$
- F**  $\frac{19\pi R^3 \rho_0}{15}$
- G**  $\frac{4\pi R^3 \rho_0}{3}$
- H**  $2\pi R^3 \rho_0$

**END OF TEST**

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