UNIVERSITY OF CAMBRIDGE

# ENGINEERING ADMISSIONS ASSESSMENT

## Specimen Paper 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 21 printed pages and 3 blank pages.*



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

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

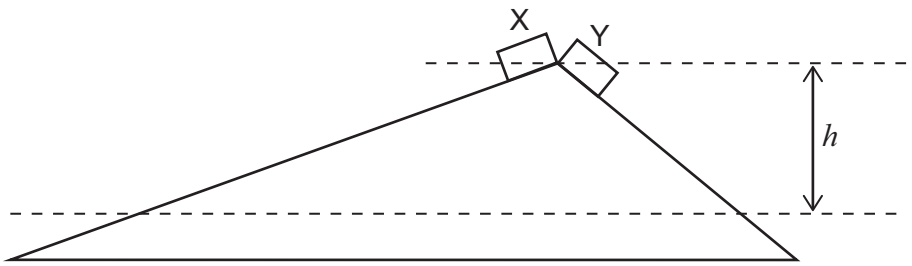
**D** 75 cm

**E** 150 cm

**F** 300 cm

**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 $v_X < v_Y$

**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.

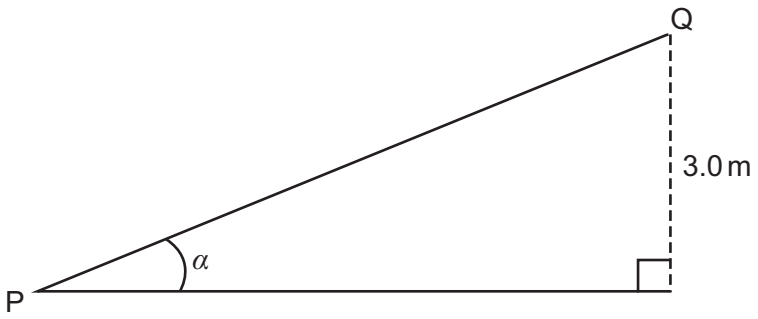
**D** The total kinetic energy after the explosion is the same as before but the total momentum has decreased.

**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.

**4** PQ is a rough plane which is inclined to the horizontal at an angle $\alpha$, 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

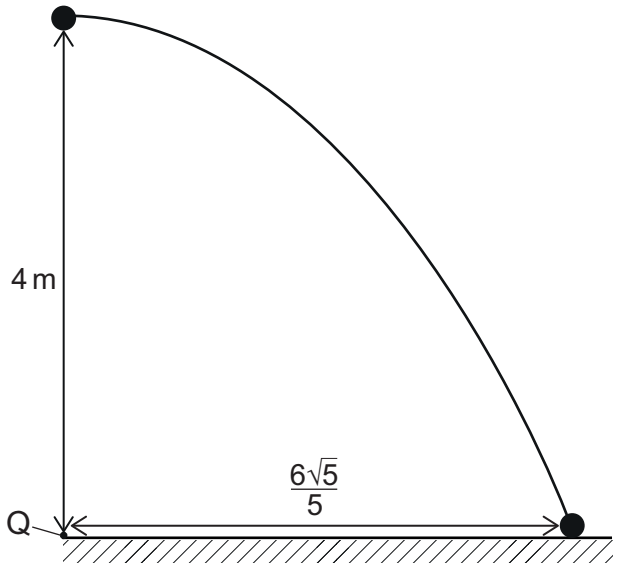
**B** 15 N

**C** 39 N

**D** 42 N

**E** 72 N

**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$^{-1}$

**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 p.d. 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** $1.1 \times 10^{-2}\ \Omega m$

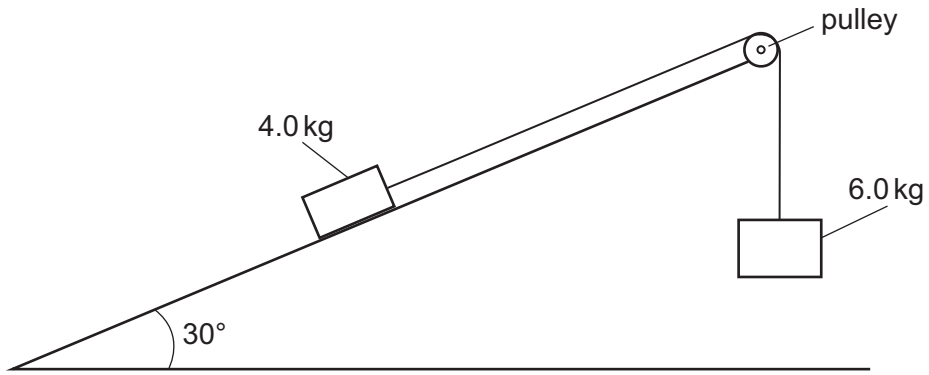
**E** $8.0 \times 10^{-2}\ \Omega m$

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

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

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

**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** $0.50\,m\,s^{-2}$

**B** $2.5\,m\,s^{-2}$

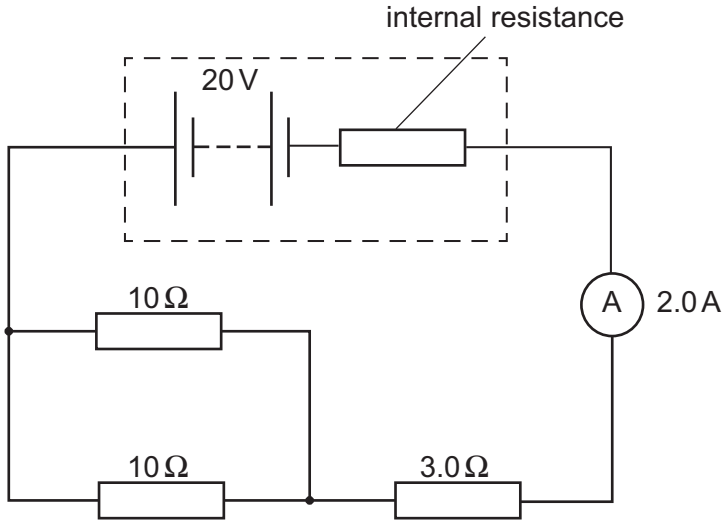
**C** $4.5\,m\,s^{-2}$

**D** $5.5\,m\,s^{-2}$

**E** $6.25\,m\,s^{-2}$

**F** $8.75\,m\,s^{-2}$

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




What is the internal resistance of the battery?

**A** 2.0 Ω

**B** 4.0 Ω

**C** 7.0 Ω

**D** 10 Ω

**E** 18 Ω

**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

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

What is the total power being transferred by the cables?

(Young modulus of steel $= 2.0 \times 10^{11}\,\text{Pa}$)

**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

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

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

**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 N kg$^{-1}$)

**A** 0.10 N cm$^{-1}$

**B** 0.17 N cm$^{-1}$

**C** 0.25 N cm$^{-1}$

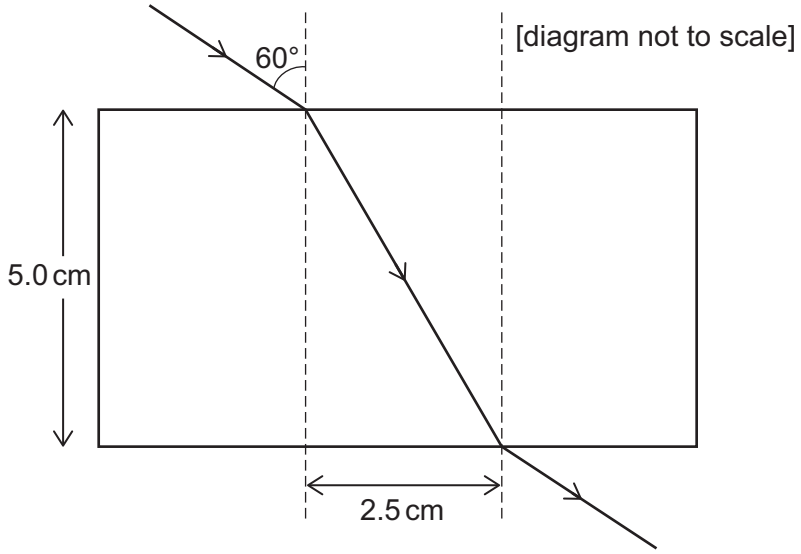
**D** 0.33 N cm$^{-1}$

**E** 0.50 N cm$^{-1}$

**F** 0.67 N cm$^{-1}$

**G** 1.0 N cm$^{-1}$

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

**15** Two smooth spheres of masses 3 kg and 1 kg are moving towards each other along a

straight line. Their speeds are $2\,m\,s^{-1}$ and $6\,m\,s^{-1}$ 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** $3\,m\,s^{-1}$

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

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

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

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

**16** Two point masses, P and Q, are 60 m 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** 2.5 s

**B** 3.0 s

**C** 3.5 s

**D** 6.0 s

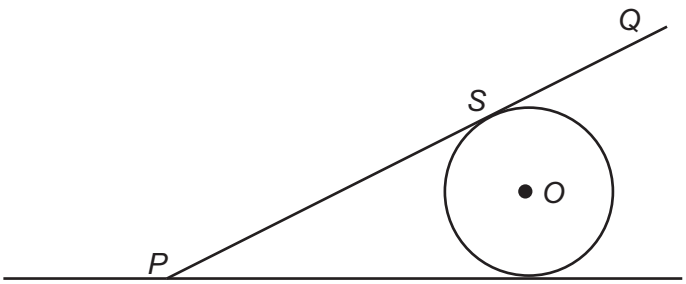
**E** 6.5 s

**F** 7.0 s

**G** 10 s

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

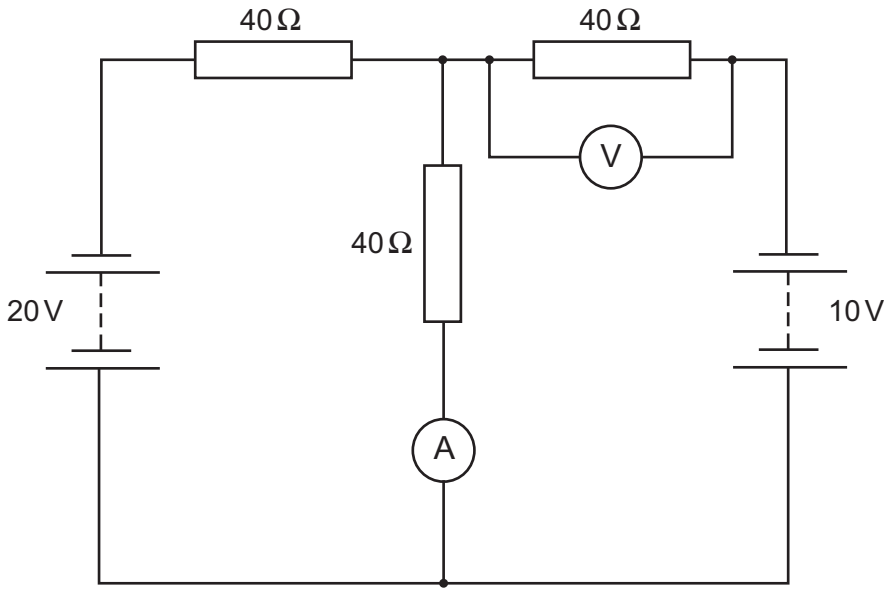
**C** $\frac{5\sqrt{3}g}{3}$

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

**E** $5g$

**F** $10g$

**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?

| | *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 |

**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

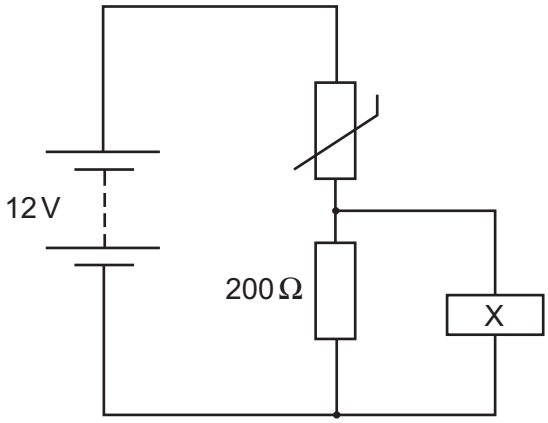
**H** 2200 Pa

**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 $\mu$ is a positive constant and $b > 1$.

X is a component with very high resistance that emits light when the p.d. 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 $(1/\mu)\ (\log_b 1200 - \log_b R_0)$

**END OF TEST**

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