Year 12 Physics

Mock Test

Time Allowed: 1 Hour 30 Minutes

Total Marks: 90

03 May 2025

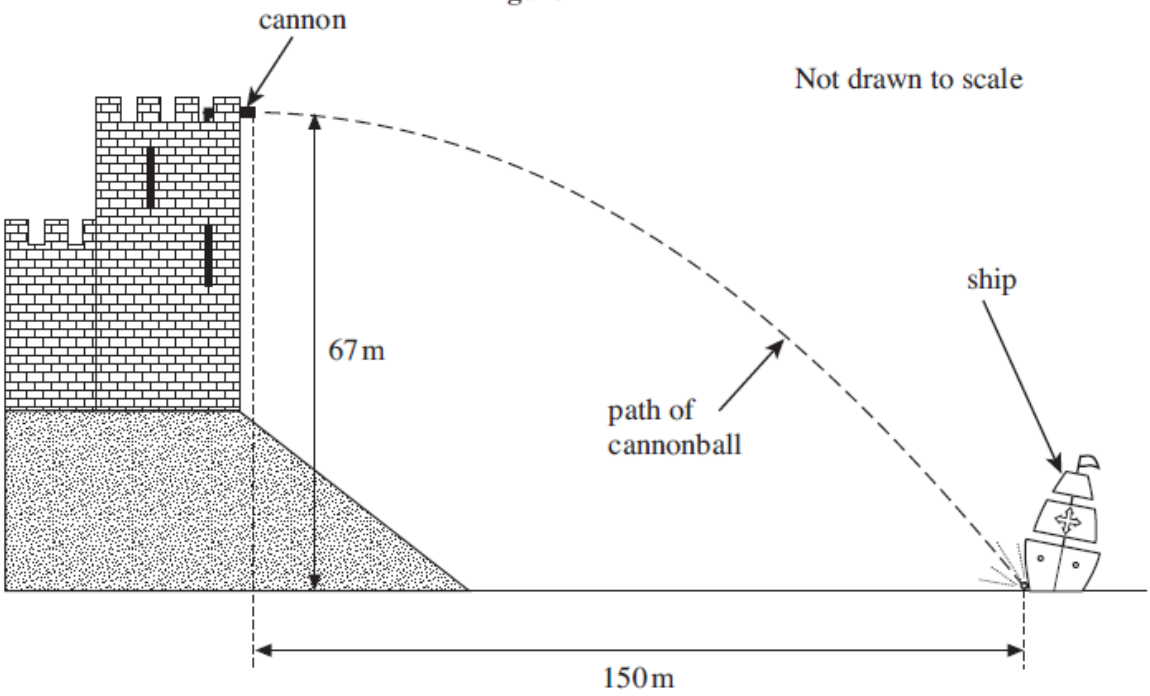
Calculator Allowed

Full Name of Student: ……

1.

In a castle, overlooking a river, a cannon was once employed to fire at enemy ships. One ship was hit by a cannonball at a horizontal distance of 150 m from the cannon as shown in **Figure 2**. The height of the cannon above the river was 67 m and the cannonball was fired horizontally.

Figure 2



(a) (i) Show that the time taken for the cannonball to reach the water surface after being fired from the cannon was 3.7 s. Assume the air resistance was negligible.

(2 marks)

(a) (ii) Calculate the velocity at which the cannonball was fired. Give your answer to an appropriate number of significant figures.

answer = ... $m\,s^{-1}$

(2 marks)

(a) (iii) Calculate the vertical component of velocity just before the cannonball hit the ship.

answer = ... $m\,s^{-1}$

(2 marks)

(a) (iv) By calculation or scale drawing, find the magnitude and direction of the velocity of the cannonball just before it hit the ship.

velocity = ... $m\,s^{-1}$

direction = ...

(4 marks)

(b) (i) Calculate the loss in gravitational potential energy of the cannonball.
mass of the cannonball = 22 kg

answer = ... J

(1 mark)

(b) (ii) Describe the energy changes that take place from the moment the cannonball leaves the cannon until just before it hits the water. Include the effects of air resistance.

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(2 marks)

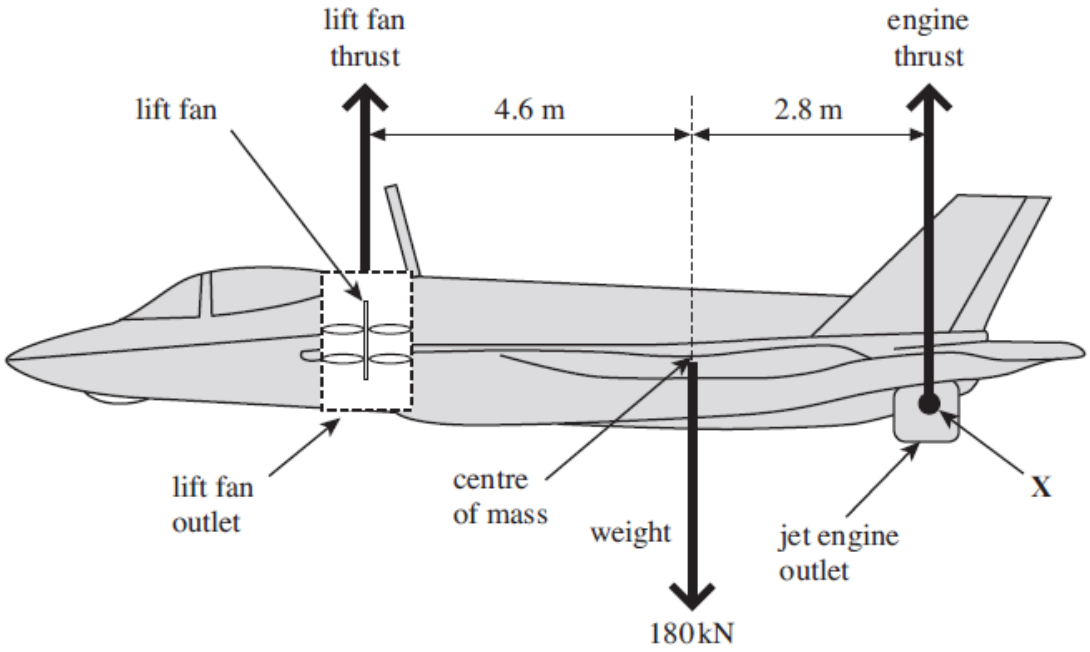
[Total for Question 1 = 13 marks]

Question 2 is on the next page.

2.

Figure 3 shows an aircraft designed to take off and land vertically and also to hover without horizontal movement. In order to achieve this, upward lift is produced by directing the jet engine outlet downwards. The engine also drives a vertical lift fan near the front of the aircraft. The weight of the aircraft is 180 kN. The distance between the lift fan and the centre of mass is 4.6 m and the distance between the jet engine outlet and the centre of mass is 2.8 m.

Figure 3



(a) (i) Calculate the moment caused by the weight of the aircraft about the point **X**.

answer = ... N m
(2 marks)

(a) (ii) By taking moments about **X**, calculate the lift fan thrust if the aircraft is to remain horizontal when hovering.

answer = ... N
(3 marks)

(a) (iii) Calculate the engine thrust in **Figure 3**.

answer = ... N
(1 mark)

(b) Having taken off vertically, the jet engine outlet is turned so that the engine thrust acts horizontally. The aircraft accelerates horizontally to a maximum velocity. The forward thrust produced by the jet is 155 kN. The weight of the aircraft is 180 kN.

(b) (i) When the resultant horizontal force is 155 kN, calculate the horizontal acceleration of the aircraft.

answer = ... ms^{-2}
(2 marks)

(b) (ii) State and explain **one** characteristic of the aircraft that limits its maximum horizontal velocity.

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(2 marks)

(b) (iii) On the axes below, sketch the velocity-time graph for the horizontal motion of the aircraft as it accelerates from zero to its maximum horizontal velocity.

(2 marks)

(c) State how a velocity-time graph could be used to find the maximum acceleration.

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(1 mark)

[Total for Question 2 = 13 marks]

3.

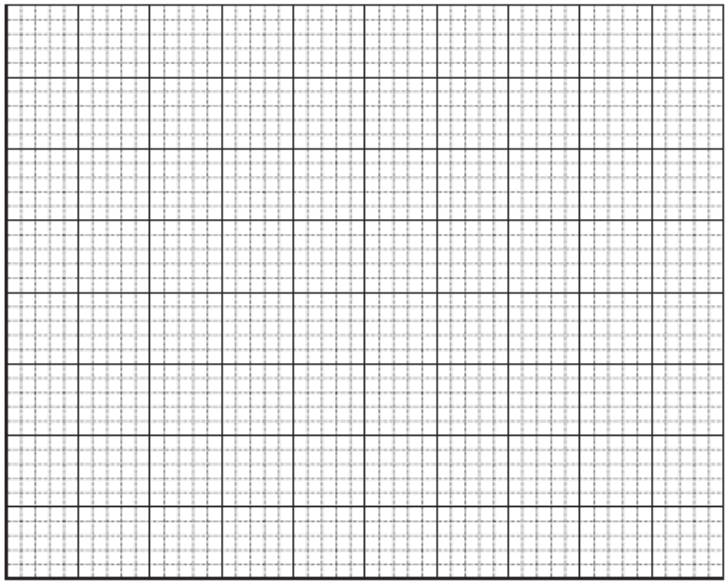
The table below shows the results of an experiment where a force was applied to a sample of metal.

(a) On the axes below, plot a graph of stress against strain using the data in the table.

(3 marks)

strain / 10^{-3}	0	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
stress / 10^{8} Pa	0	0.90	2.15	3.15	3.35	3.20	3.30	3.50	3.60	3.60	3.50

stress / 10^{8} Pa



strain / 10^{-3}

(b) Use your graph to find the Young modulus of the metal.

answer = ... Pa

(2 marks)

(c) A 3.0 m length of steel rod is going to be used in the construction of a bridge. The tension in the rod will be 10 kN and the rod must extend by no more than 1.0 mm. Calculate the minimum cross-sectional area required for the rod.

Young modulus of steel = 1.90×10^{11} Pa

answer = ... m^2

(3 marks)

[Total for Question 3 = 8 marks]

4.

(a) State the principle of superposition of waves.

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..... **[2]**

(b) Coherent red light of wavelength 6.00×10^{-7} m is incident normally on a pair of narrow slits $\mathbf{S_1}$ and $\mathbf{S_2}$. A pattern of bright and dark lines, called fringes, appears close to point **P** on a distant viewing screen.

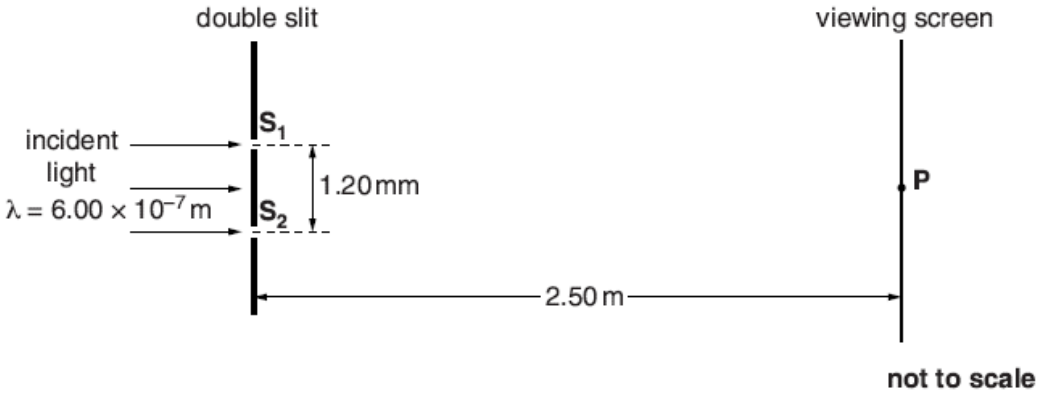

Fig. 5.1

(i) Explain the term *coherent*.

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..... **[1]**

(ii) State a value of the path difference between the light waves from slits $\mathbf{S_1}$ and $\mathbf{S_2}$ to the screen to produce a **dark** fringe on the screen.

path difference = ... m **[1]**

(iii) Calculate the separation of adjacent dark fringes on the screen near to point **P**.

Use the following data: slit separation $\mathbf{S_1S_2}$ = 1.20 mm
distance between slits and screen = 2.50 m

separation = ... m **[3]**

(iv) State and explain the effect, if any, on the **position** of the bright fringes on the screen when each of the following changes is made, separately, to the apparatus.

1 The light source is changed from a red to a yellow light source.

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..... **[2]**

2 Slit S_1 is made wider than slit S_2 but their centres remain the same distance apart.

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..... **[2]**

3 The viewing screen is moved closer to the slits.

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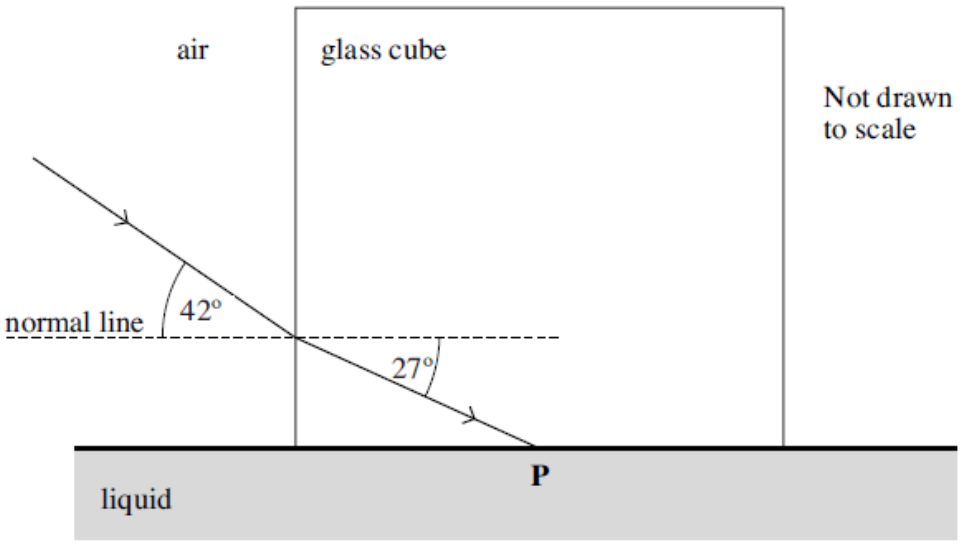
..... **[2]**

[Total for Question 4 = 13 marks]

5.

A glass cube is held in contact with a liquid and a light ray is directed at a vertical face of the cube. The angle of incidence at the vertical face is then decreased to 42° as shown in **Figure 8**. At this point the angle of refraction is 27° and the ray is totally internally reflected at **P** for the first time.

Figure 8



(a) Complete **Figure 8** to show the path of the ray beyond **P** until it returns to air.

(3 marks)

(b) Show that the refractive index of the glass is about 1.5.

(2 marks)

(c) Calculate the critical angle for the glass-liquid boundary.

answer = ... degrees

(1 mark)

(d) Calculate the refractive index of the liquid.

answer = ...

(2 marks)

[Total for Question 5 = 8 marks]

Question 6 is on the next page.

6.

(a) Describe and explain the photoelectric effect in terms of photons interacting with the surface of a metal.

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.....[6]

(b) An X-ray machine in a hospital emits X-rays of wavelength 4.0×10^{-10} m and of power 1.4 W.

(i) Calculate the energy of each X-ray photon

energy = ... J

[2]

(ii) Calculate the number of photons emitted per second from the X-ray machine.

number = ... s^{-1} [3]

[Total for Question 6 = 11 marks]

Question 7 is on the next page.

7.

A resistor **X** is constructed from a rod of cross-sectional area $9.0 \times 10^{-6}\,m^2$ and length 0.012 m as shown in Fig. 1.1. The resistivity of the material of the rod is $2.4\,\Omega\,m$.

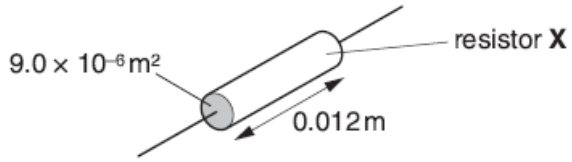

Fig. 1.1

(a) Show that the resistance of the resistor **X** is $3.2\,k\Omega$.

[2]

(b) The power rating of resistor **X** is 0.125 W. Show that the maximum potential difference which should be applied safely across the resistor is 20 V.

[2]

(c) A student needs a resistor of the same resistance as **X** but with a power rating of 0.50 W. The only resistors available are identical to **X**. It is suggested that four of these resistors could be connected as shown in Fig. 1.2 to solve the problem. The potential difference across the combination of resistors is 40 V.

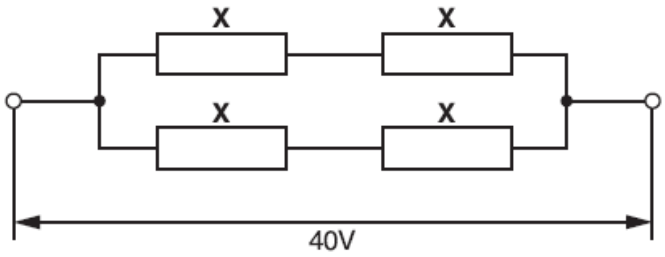

Fig. 1.2

(i) Show that the total resistance of the combination in Fig. 1.2 is 3.2 kΩ.

[2]

(ii) Show that the power dissipation in each resistor is 0.125 W.

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..... **[2]**

(d) Another resistor **Y** is constructed from the same material but has twice the length and twice the diameter of resistor **X**.

(i) Show that the resistance R_Y of **Y** is half the resistance R_X of resistor **X**.

[2]

(ii) The two resistors **X** and **Y**, where $R_Y = R_X/2$, are connected in series to a d.c. power supply as shown in Fig. 1.3.

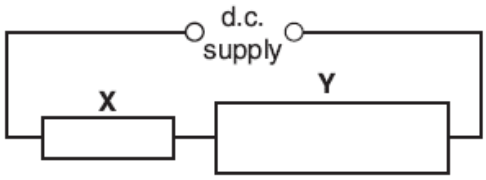

Fig. 1.3

State and explain which resistor dissipates greater power.

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..... **[3]**

[Total for Question 7 = 13 marks]

8.

(a) The following electrical quantities are often used when analysing circuits. Draw a straight line from each quantity on the left-hand side to its correct units on the right-hand side.

potential difference	Cs^{-1}
resistance	JC^{-1}
power	VA^{-1}
current	Js^{-1}

[3]

(b) Fig. 3.1 shows a battery of e.m.f. 6.0V and negligible internal resistance connected in series with a thermistor and a 560Ω resistor.

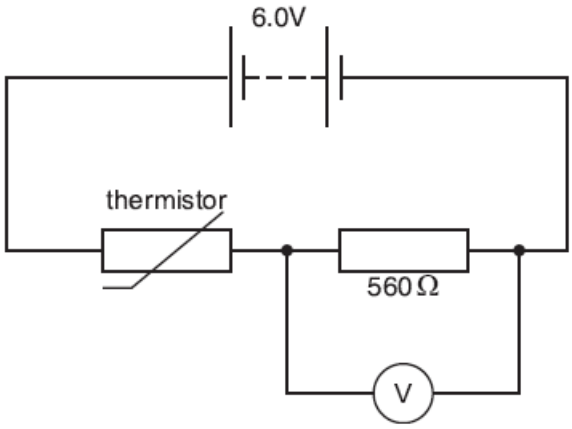

Fig. 3.1

The voltmeter across the resistor has infinite resistance.

(i) The reading on the voltmeter is 2.4V. Calculate the resistance R_T of the thermistor.

R_T = ... Ω **[3]**

(ii) Calculate the current in the circuit.

current = ... A **[1]**

(c) The variation of resistance with temperature for this thermistor is shown in the graph of Fig. 3.2.

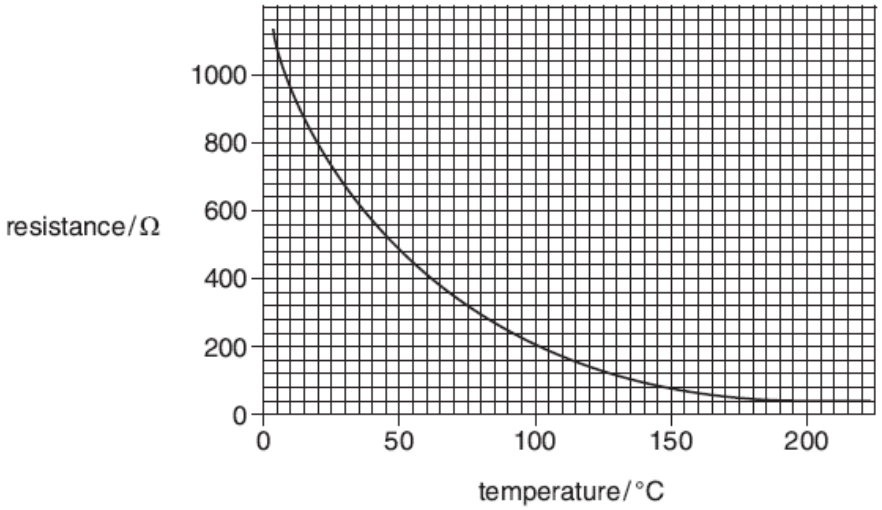

Fig. 3.2

(i) Use the graph to determine the temperature of the thermistor when its resistance is 800 Ω.

temperature = ... °C **[1]**

(ii) State and explain, without calculation, how the reading of the voltmeter in Fig. 3.1 will change as the temperature of the thermistor increases to 80 °C.

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..... **[3]**

[Total for Question 8 = 11 marks]

- End of Test -
