

Section A

Answer **all** the questions in this section.

- 1 A cyclist travels along a straight road. The displacement-time (s - t) graph below represents the cyclist's journey.

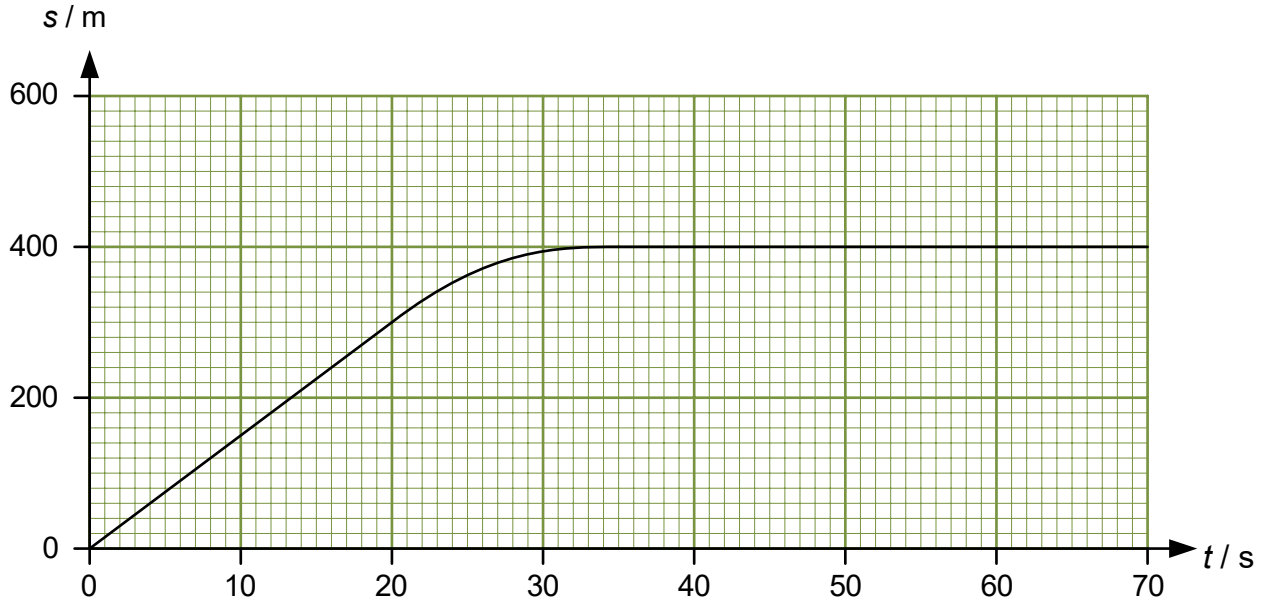


Fig. 1.1

- (a) State the displacement of the cyclist from his starting point to $t = 35$ s.

displacement = [1]

- (b) Calculate the velocity of the cyclist during the first 20 s of the journey.

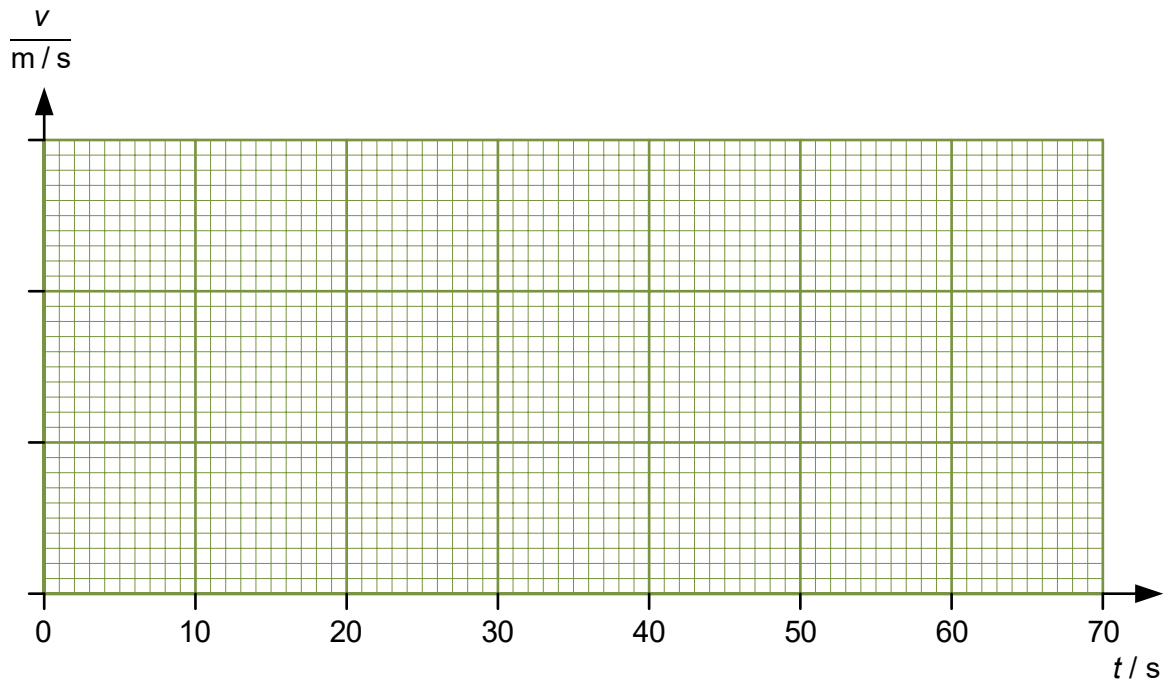
velocity = [2]

- (c) Using the s - t graph, describe the motion of the cyclist between $t = 20$ s and $t = 35$ s. Explain how the shape of the graph shows this.

.....

 [2]

- (d) On the grid provided, sketch the velocity-time (v - t) graph for the entire journey from $t = 0$ to $t = 70$ s. Label the values on the v -axis clearly.



[3]

[8 marks]

- 2 Fig. 2.1 shows a simplified cross-section of an industrial hydraulic oil pump system. A force F_1 is applied downwards on Piston 1. The cross-sectional area of piston 1, A_1 , is 0.020 m^2 . It transmits pressure through an incompressible oil to move Piston 2. The cross-sectional area of piston 2, A_2 , is 0.016 m^2 .

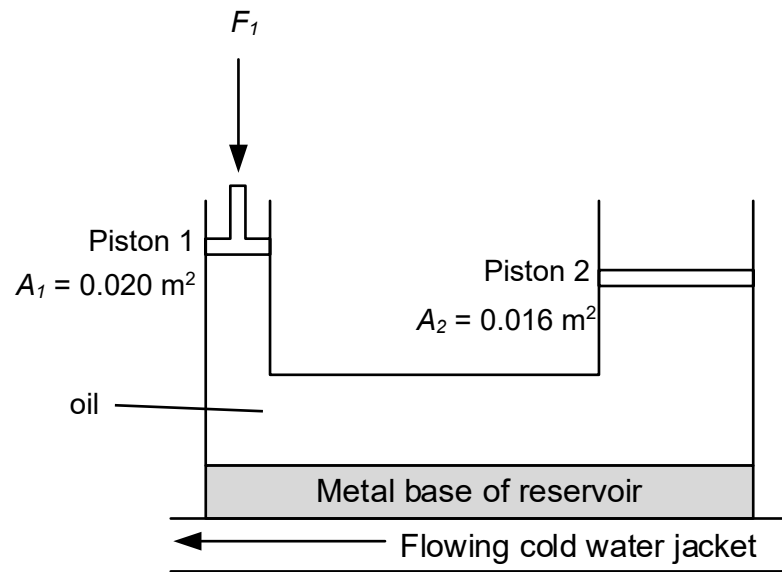


Fig. 2.1

- (a) If $F_1 = 150 \text{ N}$,
 (i) calculate the pressure exerted on the oil by Piston 1.

pressure = [2]

- (ii) determine the upward force exerted by the oil on Piston 2.

upward force = [2]

- (b)** Due to friction between the moving parts, the hydraulic oil absorbs heat, causing its temperature to rise. To prevent overheating, a cold water jacket surrounds the metal base of the oil reservoir. The hot hydraulic oil transfers its excess thermal energy through the metal base of the reservoir into the flowing cold water.

- (i)** Using particulate model of matter, describe how thermal energy is conducted within the solid metal base.

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.....

.....

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.....

..... [2]

- (ii)** Explain how convection current is formed in the cold water jacket to efficiently remove the heat.

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.....

.....

..... [2]

[8 marks]

- 3 Fig. 3.1 shows a 12 kg uniform wooden barrier plank of length 3.0 m pivoted at point P. The pivot is located 0.50 m from the left end of the plank. An electric motor is attached via a vertical cable at pivot A to pull down and raise the barrier. The barrier is currently held horizontally in equilibrium. The gravitational field strength is 10 N / kg.

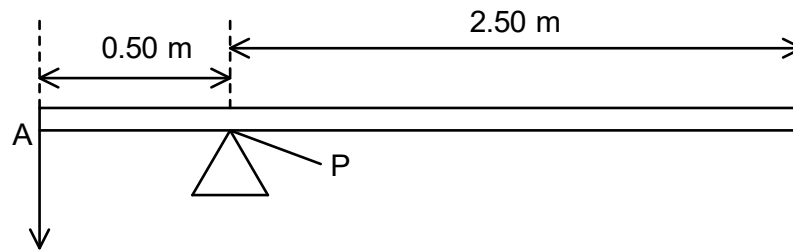


Fig. 3.1

- (a) State **two** conditions required for the uniform barrier to remain in static equilibrium.

.....

.....

.....

..... [2]

- (b) Calculate the downward pulling force exerted by the vertical cable at point A to keep the barrier horizontal.

downward pulling force = [3]

- (c) The motor now pulls point A down vertically by a distance of 0.20 m in a time of 1.5 s to raise the other end of the barrier. Assuming the pulling force calculated in part (b) remains constant during this motion, calculate the useful power output of the motor.

useful power output = [2]

[7 marks]

- 4 A ship uses sonar to detect the depth of the ocean floor. The sonar system sends out a pulse of ultrasound and detects the reflected pulse returning from the ocean floor.

The speed of sound in seawater is 1500 m / s. The time between sending the pulse and receiving the reflected pulse is 0.40 s.

- (a) State what is meant by a *longitudinal wave*.

.....
 [1]

- (b) State **one** difference and **one** similarity between ultrasound and the sound heard by a human ear.

Difference:

.....

Similarity:

..... [2]

- (c) Calculate the depth of the ocean floor below the ship.

depth = [2]

- (d) The frequency of the ultrasound pulse is 40 000 Hz. Calculate the wavelength of the ultrasound in seawater.

wavelength = [2]

- (e) State one other use of ultrasound, other than sonar.

..... [1]

[8 marks]

- 5 A student uses a converging lens to project an image of a lamp onto a screen as shown in Fig. 5.1 below.

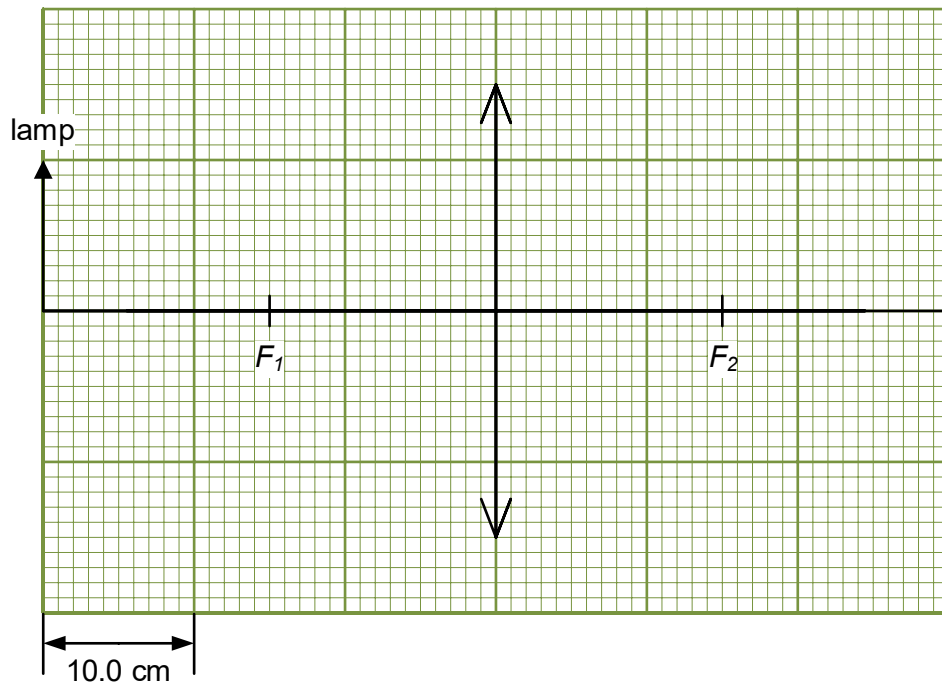


Fig. 5.1

The focal length of the lens is 15 cm. The lamp is placed 30 cm from the lens.

- (a) Define the term *principal focus* of a converging lens.

.....
 [1]

- (b) By drawing ray diagram on Fig. 5.1, locate the image and label the image "I". [3]

- (c) The student moves the lamp closer to the lens so that it is now 20 cm from the lens. Describe how the size and distance of the image change.

.....
 [2]

[6 marks]

- 6 (a) A student investigates the electrical characteristics of a resistor R and a filament lamp L. Fig. 6.1 shows the I - V characteristic graphs for both components.

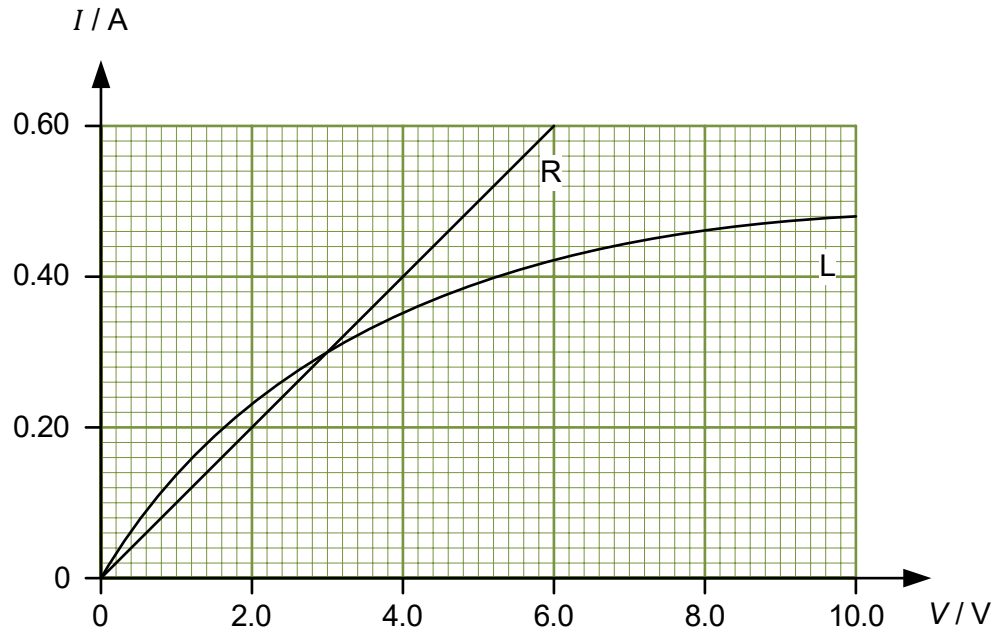


Fig. 6.1

- (i) State *Ohm's Law*.

.....
 [1]

- (ii) State which component, R or L, is an ohmic conductor. Explain how the I - V graph shows this.

.....
 [1]

- (iii) Using Fig. 6.1, determine the resistance of lamp L at a potential difference of 6.0 V.

resistance = [2]

- (b) Fig. 6.2 below shows a fixed resistor of $50\ \Omega$ and a light-dependent resistor connected in parallel. Under dark conditions, the resistance of the light-dependent resistor is larger than $50\ \Omega$. Under bright conditions, the resistance of the light-dependent resistor is lower than $50\ \Omega$.

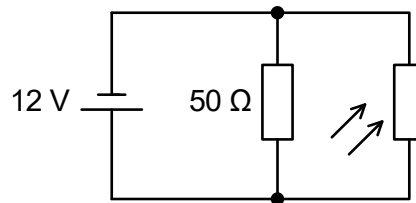


Fig. 6.2

- (i) As the environment changes from dark to bright, describe and explain how the total current drawn by the battery changes.

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 [2]

- (ii) A circuit using the same light-dependent resistor has been set up as shown in Fig. 6.3 below.

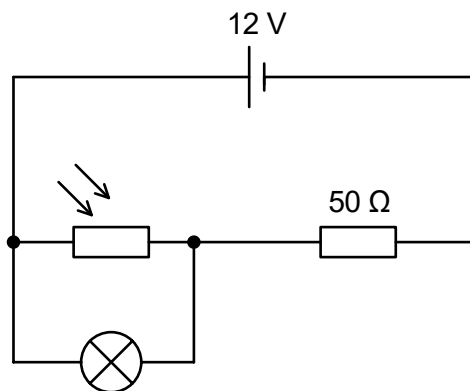


Fig. 6.3

Explain how the lamp operates under dark and bright conditions.

.....

 [2]

[8 marks]

- 7 (a) Fig. 7.1 shows a coil ABCD that can turn between the two poles of a magnet. Bare metal paper clips support and pass current into and out of the coil.

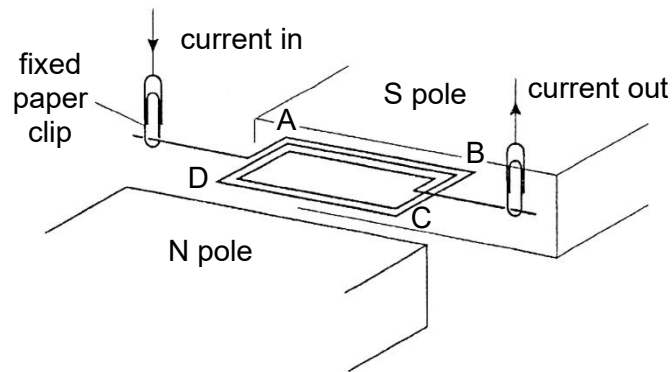


Fig. 7.1

- (i) State the direction of the force on the side AB.
- [1]
- (ii) A student turns the coil through 180° so that AB is close to the N pole of the magnet.
- 1 State the direction of the force on side AB of the coil.
- [1]
- 2 The student releases the coil. Explain why the coil does **not** rotate continuously.
-
-
- [1]

- (b) Fig. 7.2 shows a negatively-charged metal sphere held with a wooden handle. When a student moves the sphere near the copper plate, the galvanometer indicates a momentary deflection. A galvanometer is an instrument used to measure small electrical current and detect its direction.

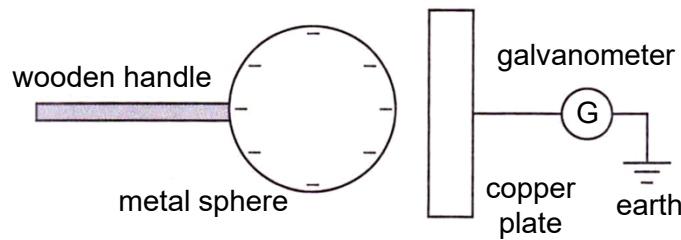


Fig. 7.2

- (i) Explain why there is a momentary deflection in the galvanometer.

.....

.....

..... [2]

- (ii) On Fig. 7.2, draw the distribution of the charges induced on the metal plate after the deflection. [1]

- (iii) On Fig. 7.2, draw the direction of the conventional current in the wire connecting the copper plate and galvanometer. [1]

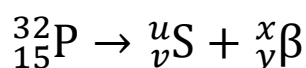
[7 marks]

- 8 A radioactive isotope, phosphorus-32 ($^{32}_{15}\text{P}$), is used in medical research. It decays by emitting beta (β) particles and has a half-life of 14 days.

- (a) State the name and number of each type of sub-atomic particle found in the nucleus of phosphorus-32.

.....
 [1]

- (b) Phosphorus-32 decays by beta emission to form an isotope of sulfur (S). Complete the nuclide equation for this decay.



$u =$ $v =$ $x =$ $y =$ [2]

- (c) A sample of phosphorus-32 is placed near a Geiger-Müller tube and counter in a laboratory. The measured count rate on the counter is 700 counts per minute, but the actual count rate at the start of the experiment is 640 counts per minute.

- (i) Suggest what is meant by *background radiation*.

.....
 [1]

- (ii) Calculate the time taken in days for the corrected count rate to fall to 80 counts per minute.

time taken = [2]

- (d) State one use of radioactive isotopes in medicine and explain why the short half-life of phosphorus-32 is important for this use.

.....

 [2]

[8 marks]

- 9 A team of planetary scientists drops an identical 2.0 kg spherical research probe into the atmospheres of four different newly discovered exoplanets (J, K, L and M). The probe is dropped from rest at a high altitude on each planet.

The atmospheres of these planets have different gas densities, which create varying amounts of air resistance. The engineers record the local gravitational field strength (g), the initial acceleration of the probe at the moment of release, and the final terminal velocity reached by the probe. The data is compiled in Table 9.1.

Table 9.1

Planet	Gravitational field strength, g / N / kg	Initial acceleration at release / m / s ²	Terminal velocity reached / m / s
J	4.0	4.0	40
K	6.0	6.0	20
L	10.0	10.0	10
M	12.0	12.0	30

- (a) State the relationship between the gravitational field strength of a planet and the initial acceleration of the probe at the exact moment of release ($t = 0$ s). Explain this relationship.

.....

 [2]

- (b) While falling through the atmosphere of planet M, the probe encounters an upward air resistance force of 4.0 N at a certain velocity. Calculate the acceleration of the probe at this specific moment.

acceleration = [2]

- (c) Compare the atmospheric gas densities of planet K and planet L. Deduce which planet has a denser atmosphere using data from Table 9.1. Explain your deduction clearly.

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.....

.....

..... [3]

- (d) The probe is falling at its terminal velocity on planet J.

- (i) State the maximum air resistance acting on the probe during its fall.

maximum air resistance = [1]

- (ii) Describe the main energy transfer during the fall.

.....

.....

..... [2]

[10 marks]

Section B

Answer **one** question from this section.
Answer either **Question 10** or **Question 11**.

- 10** Fig. 10.1 shows a wind turbine used to generate electricity. The turbine has blades of radius, r , 40 m. The wind blows at a speed, v , of 12 m / s. The density of air is 1.2 kg / m³.

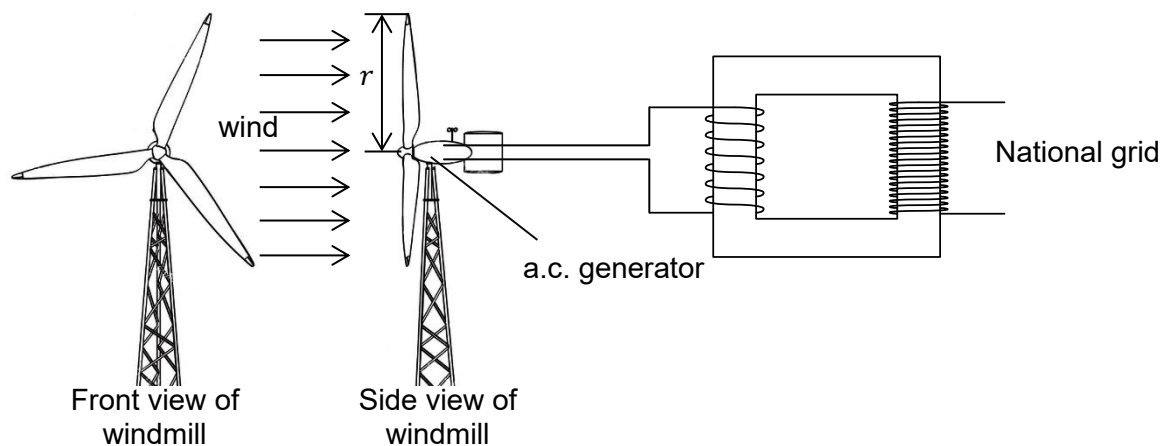


Fig. 10.1

- (a)** The volume of air passing through the blades each second is given by the expression:

$$\text{volume per second} = \pi \times r^2 \times v$$

where r is the blade radius and v is the wind speed.

- (i)** Calculate the volume of air passing through the blades each second.

volume in per second = [1]

- (ii)** Hence, calculate the kinetic energy of the air passing through the windmill in one second.

kinetic energy per second = [3]

- (b) Fig. 10.2 shows the a.c. generator connected to the windmill and the transformer. Fig. 10.3 shows the output voltage of the windmill at a given time.

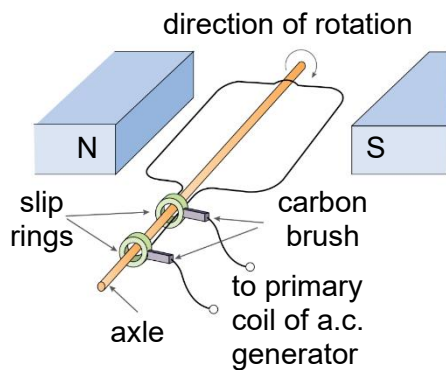


Fig. 10.2

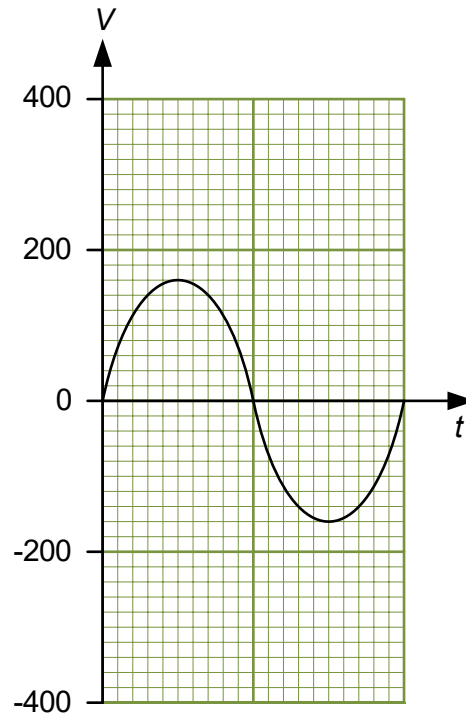


Fig. 10.3

- (i) State the value of the induced e.m.f. at the point where the plane of coil is parallel to the magnetic field. Explain your answer.

induced e.m.f = [1]

..... [1]

- (ii) Windspeed decreases so that the coil rotates at half its original speed. Sketch the new waveform on Fig. 10.3. [2]

- (c) The electrical output of the turbine is at a voltage of 690 V. This is stepped up to 132 000 V for transmission across the national grid. Explain why a high voltage is used for transmission of electrical energy across the national grid.

..... [1]

- (d) Wind is a renewable energy resource. State one disadvantage of using wind turbines to generate electricity, compared to using fossil fuels.

..... [1]

[10 marks]

- 11 A student heats a metal block using an electrical heater. Fig. 11.1 shows the apparatus.

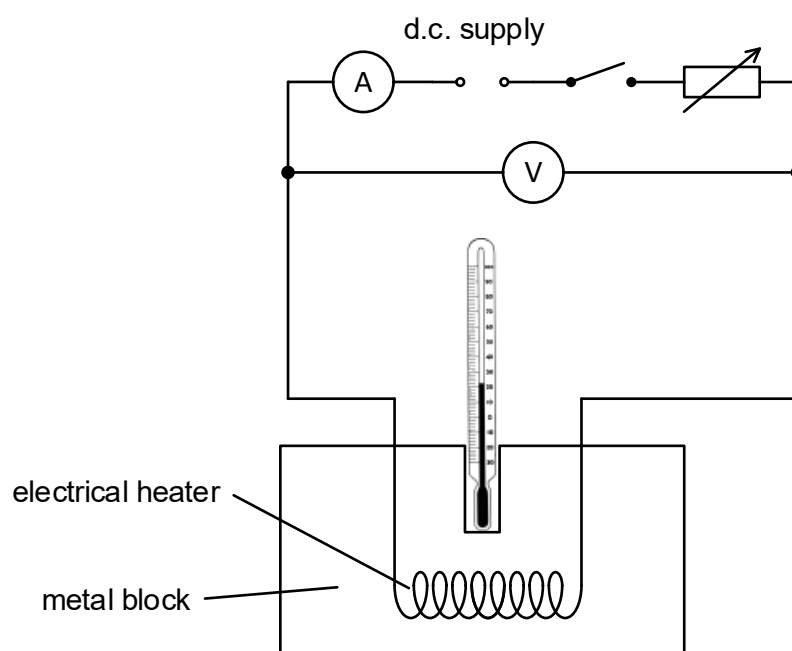


Fig. 11.1

The heater has a power of 50 W. The student switches on the heater and records the temperature of the block every 30 seconds. Fig. 11.2 shows the temperature-time graph obtained.

temperature / °C

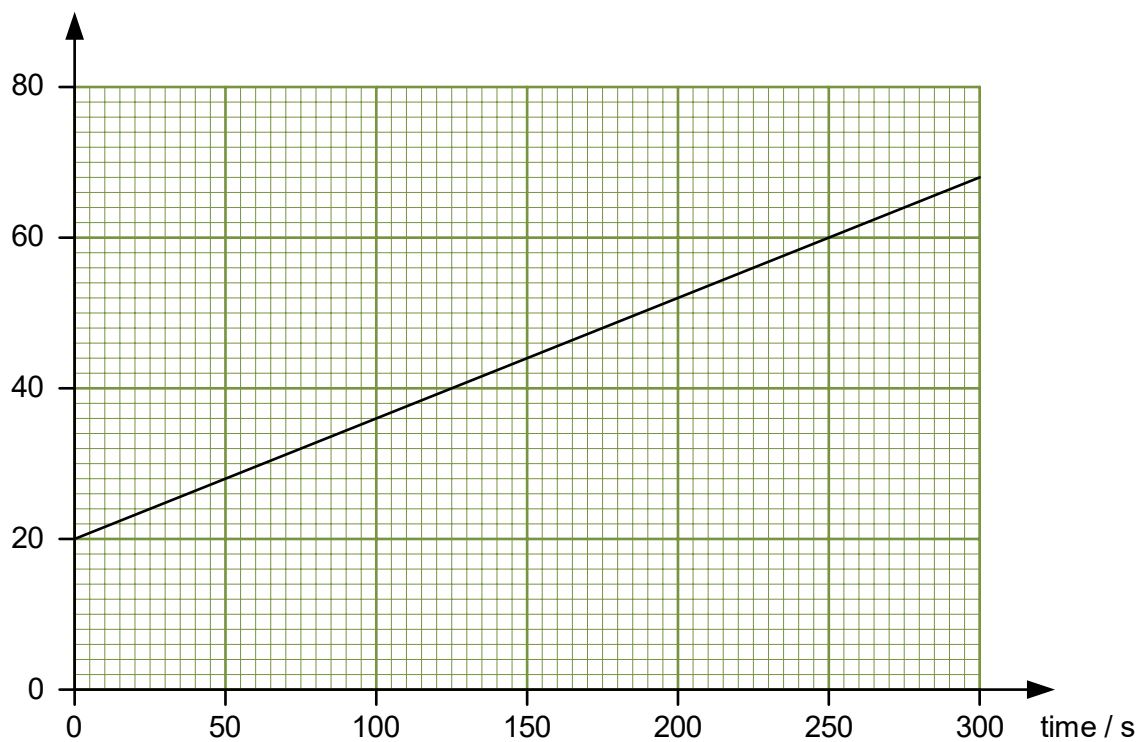


Fig. 11.2

- (a) State the function of the variable resistor.

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..... [1]

- (b) Compare the motion of the particles at 20 °C and at 60 °C.

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

- (c) Using Fig. 11.2, determine the rate of temperature rise of the metal block in °C / s.

temperature rise = [1]

- (d) The mass of the metal block is 0.80 kg.

- (i) Calculate specific heat capacity of the metal.

specific heat capacity = [2]

- (ii) State the difference between heat capacity and specific heat capacity.

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

(e) The student repeats the experiment using a block of a different metal of the same mass. The specific heat capacity of the second metal is greater than that of the first metal.

(i) State and explain how the gradient of the temperature-time graph for the second metal compares with the gradient for the first metal, when the same heater is used.

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

(ii) Explain, using ideas about particles, what is meant by specific heat capacity of the second metal is greater than that of the first metal.

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

[10 marks]