Name:		Centre/Index Number:		Class:	

DUNMAN HIGH SCHOOL
Preliminary Examination
Year 6

H2 PHYSICS — 9749/02

Paper 2 Structured Questions

15 September 2023

2 hours

Candidates answer on the Question Paper

READ THESE INSTRUCTIONS FIRST

Write your centre number, index number, name and class at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the question paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	10
2	9
3	6
4	11
5	7
6	10
7	7
8	20
Total	80

This document consists of **21** printed pages and **1** blank page.

Data

speed of light in free space,	c =	3.00×10^{8} m s^{-1}
permeability of free space,	μ_o =	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_o =	8.85×10^{-12} F m^{-1}
		$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e =	1.60×10^{-19} C
the Planck constant,	h =	6.63×10^{-34} J s
unified atomic mass constant,	u =	1.66×10^{-27} kg
rest mass of electron,	m_e =	9.11×10^{-31} kg
rest mass of proton,	m_p =	1.67×10^{-27} kg
molar gas constant,	R =	8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A =	6.02×10^{23} mol^{-1}
the Boltzmann constant,	k =	1.38×10^{-23} J K^{-1}
gravitational constant,	G =	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall,	g =	9.81 m s^{-2}

Formulae

uniformly accelerated motion	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas	W	=	$p\Delta V$
hydrostatic pressure	p	=	ρgh
gravitational potential	ϕ	=	$-Gm/r$
temperature	T/K	=	T/°C + 273.15
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}<c^2>$
mean translational kinetic energy of an ideal gas molecule	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_0 \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_0 \cos \omega t$
		=	$\pm\omega\sqrt{x_o^2 - x^2}$
electric current	I	=	$Anvq$
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential	V	=	$\frac{Q}{4\pi\varepsilon_o r}$
alternating current / voltage	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	=	$\frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_0 nI$
radioactive decay	x	=	$x_0 \exp(-\lambda t)$
decay constant	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

Answer **all** questions in the spaces provided.

1 An experiment to determine the acceleration of free fall g is conducted by projecting a stone with speed u at an angle θ to the horizontal. The horizontal distance R travelled by the stone when it returns to the level of projection is measured. Air resistance is negligible.

(a) In determining the speed of the stone, a student defines speed as "distance travelled per second".

Explain why this definition is incorrect.

....

....

....

....[2]

(b) By expressing the time of flight of the stone T in terms of g, u and θ, show that R is given by the expression

$$R = \frac{2u^2 \sin\theta \cos\theta}{g}$$

[3]

(c) The expression in **(b)** can be written as

$$R = \frac{u^2 \sin 2\theta}{g}$$

The experiment is conducted to obtain the maximum range R_0.

State the value of θ to obtain R_0.

θ = ... ° [1]

(d) The values of u and R_0 are 45.36 km h^{-1} and 16.3 m, with percentage uncertainties of 3% and 4% respectively.

Calculate the value of g and present the answer together with its uncertainty.

g = ... ± .... m s^{-2} [4]

[Total: 10]

2 A lifting bag is a diving equipment which is used to lift heavy objects underwater by means of the bag's buoyancy. To retrieve a submerged cannon of mass 800 kg and density 8000 kg m^{-3} resting on the seabed back to the surface, an uninflated lifting bag of negligible mass and volume was attached to the cannon by a diver. The density of seawater is 1050 kg m^{-3}.

(a) Explain the origin of *upthrust*.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………[1]

(b) Show that upthrust acting on the cannon is 1030 N.

[1]

Air was suddenly released into the lifting bag, causing it to inflate and the cannon to be lifted off the seabed. The variation with time of the momentum of the cannon is shown in Fig. 2.1.

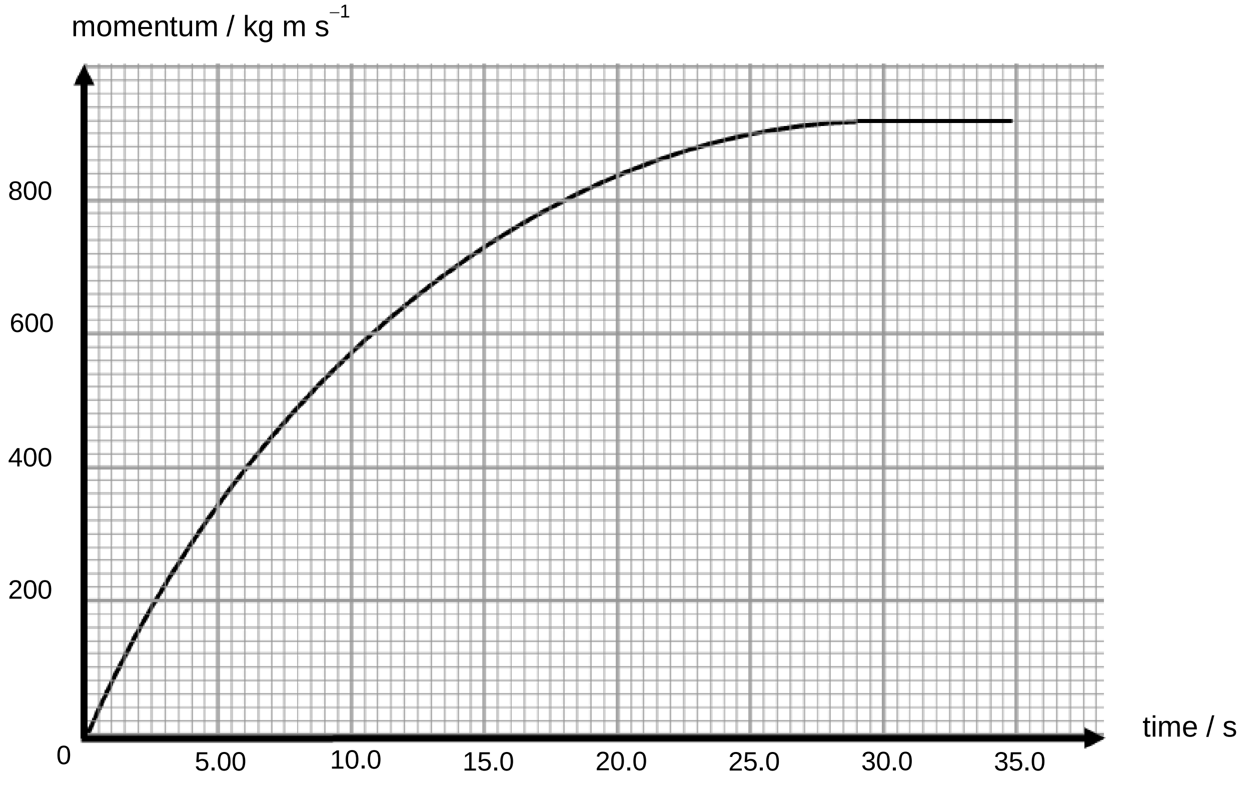


Fig. 2.1

(c) State *Newton's second law of motion.*

……

……

………………………………………………………………………………………………… [2]

(d) Explain why the momentum of the cannon increases non-linearly as shown in Fig. 2.1.

……

……

……

……

………………………………………………………………………………………………… [2]

(e) Using Fig. 2.1, estimate the volume of air that was released into the lifting bag.

volume of air = ……………………………… m^3 [3]

[Total: 9]

3 A horizontal flat plate is free to rotate about a vertical axis through its centre, as shown in Fig. 3.1.

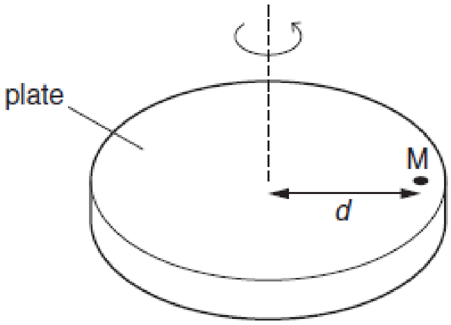


Fig. 3.1

A small mass M is placed on the plate, a distance d from the axis of rotation. The speed of rotation of the plate is gradually increased from zero until the mass is seen to slide off the plate.

The maximum frictional force F between the plate and the mass is given by the expression

$$F = 0.72W$$

where W is the weight of the mass M.

The distance d is 35 cm.

(a) Determine the maximum number of revolutions of the plate per minute for the mass M to remain on the plate. Explain your working.

number of revolutions per minute = ... [4]

(b) The plate is covered, when stationary, with mud.

Suggest and explain whether mud near the edge of the plate or near the centre will first leave the plate as the angular speed of the plate is slowly increased.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………… [2]

[Total: 6]

4 Galileo used a simple pendulum to take the time for objects to roll down an inclined plane. Fig. 4.1 shows a simple pendulum.

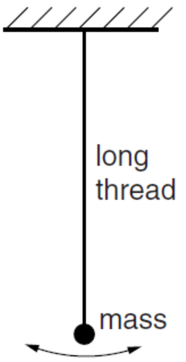


Fig. 4.1 (not to scale)

A simple pendulum oscillates with simple harmonic motion.

(a) State what is meant by *simple harmonic motion*.

....

....

....

....

.... [2]

(b) The pendulum is displaced to one side and then released at time t = 0. Fig. 4.2 shows the positions of the mass at various times during a single oscillation.

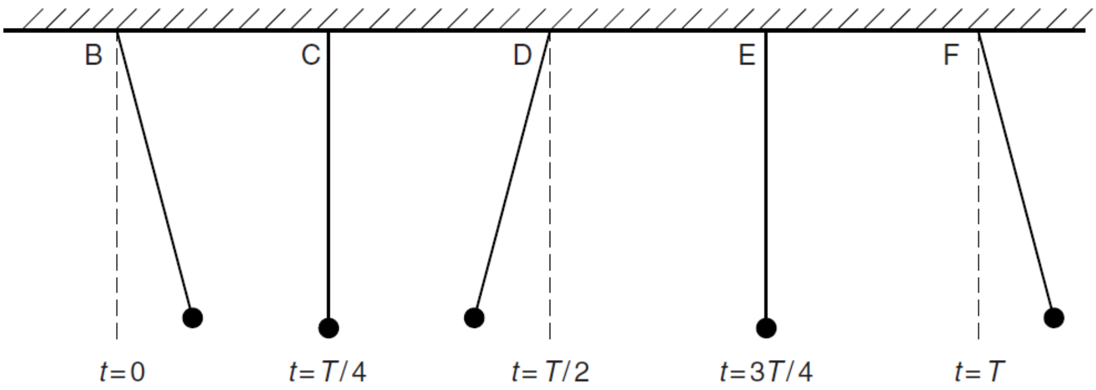


Fig. 4.2 (not to scale)

Complete the table below to describe the directions of the displacement, velocity and acceleration of the mass at times B to F using the symbols +, 0 and –.

Apply the convention that displacements, velocities and accelerations to the right are positive.

	B	C	D	E	F
displacement					
velocity					
acceleration					

[3]

(c) State the phase difference, for the pendulum in **(b)**, between

(i) the displacement and the velocity,

……………………………………………………………………………………………[1]

(ii) the displacement and the acceleration.

……………………………………………………………………………………………[1]

(d) Fig. 4.3 shows the variation of displacement *x* with time *t* for a particular pendulum.

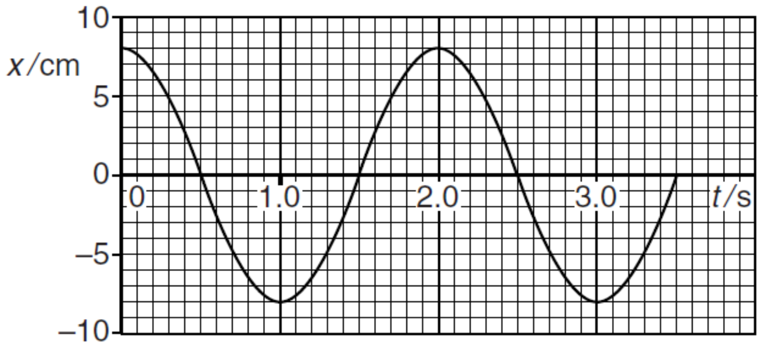


Fig. 4.3

(i) Use information from Fig. 4.3 to determine

1. amplitude,

amplitude = ... cm [1]

2. the frequency of oscillation.

frequency = ... Hz [1]

(ii) The mass *m* of the pendulum is 20 g.

1. Calculate the maximum force exerted on the mass.

maximum force = ... N [1]

2. On Fig. 4.4, sketch a graph to show how, for the time period given in Fig. 4.3, the force *F* varies with time *t*.

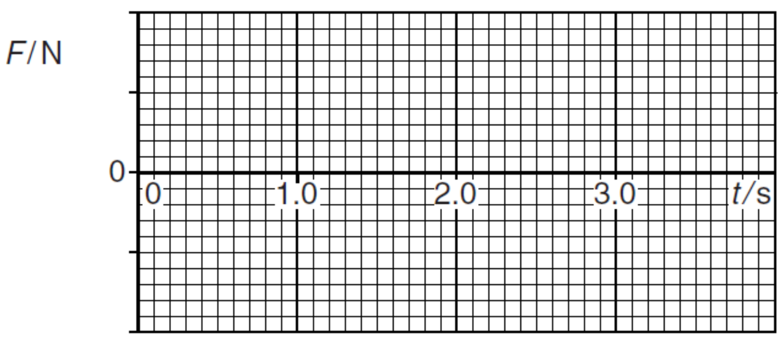


Fig. 4.4

[1]

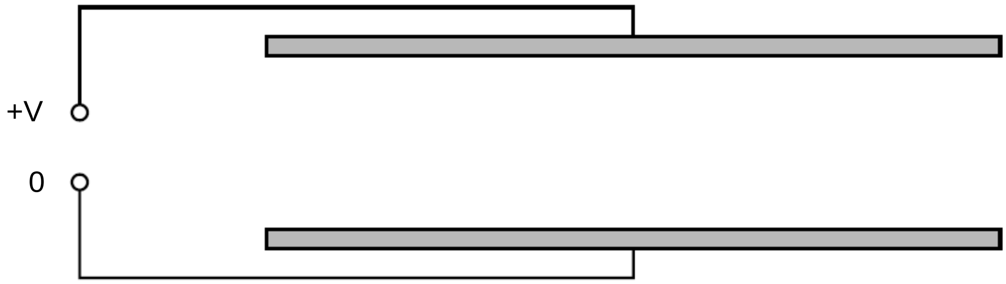
[Total: 11]

5 **(a)** Define *electric field strength*.

....

....[1]

(b) In Fig. 5.1 draw the electric field lines between the parallel plates throughout the region, including the edges.



[2]

Fig. 5.1

(c) The plates in Fig. 5.1 are separated by a distance *d* and there is a potential difference *V* between them. A small charge of +*Q*, is moved from the centre of the negative plate up to the positive plate.

State an expression for the work *W* done on the charge

(i) in terms of *V* and *Q*,

W = ... [1]

(ii) in terms of the force *F* on the charge and *d*.

W = ... [1]

(d) Use your answers to **(c)** to deduce the relationship between the electric field strength between the plates and the potential gradient.

[2]

[Total: 7]

6 The variation with the potential difference V across a filament wire of current I is shown in Fig. 6.1.

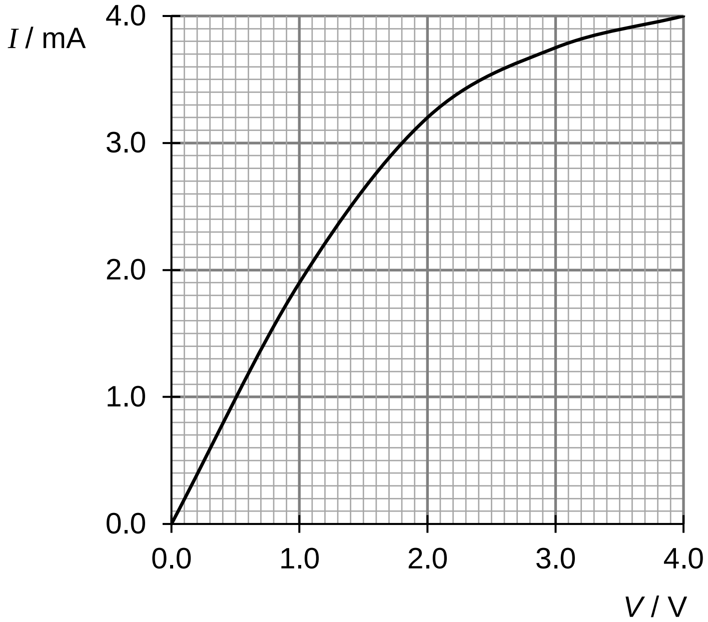


Fig. 6.1

(a) Explain how Fig. 6.1 shows that the resistance of the filament wire increases with potential difference.

....

....

....

....

.... [2]

(b) Hence, or otherwise, use Fig. 6.1 to determine the minimum value of the resistance of the filament wire.

minimum resistance = ... Ω [3]

(c) The filament wire is 2.0 m long and has a diameter of 0.046 mm.

Determine the resistivity of the wire when *V* is 4.0 V.

resistivity = ... Ω m [3]

(d) When the filament wire is connected in series with an ideal ammeter and a cell with internal resistance 0.50 Ω, the ammeter reads 1.0 mA.

Determine the e.m.f. of the cell. Give your answer to 4 significant figures.

e.m.f. = ... V [2]

[Total: 10]

7 **(a)** β-radiation is emitted during the spontaneous radioactive decay of an unstable nucleus.

(i) State the nature of a β-radiation.

.... [1]

(ii) State two properties of β-radiation.

1. ....

2. ....

[2]

(iii) Explain the meaning of *spontaneous* radioactive decay.

....

.... [1]

(b) The following equation represents the decay of a nucleus of hydrogen-3 by the emission of β radiation.

Complete the equation.

$$^{3}_{1}H \rightarrow ^{\cdots\cdots}_{\cdots\cdots}He + ^{\cdots\cdots}_{\cdots\cdots}\beta$$

[1]

(c) The β-particle is emitted with an energy of 5.7×10^3 eV.

Calculate the speed of the β-particle.

speed = ... m s^{-1} [2]

[Total: 7]

8 Wind power can be used for the generation of electric power. Fig. 8.1 illustrate one particular type of wind turbine.

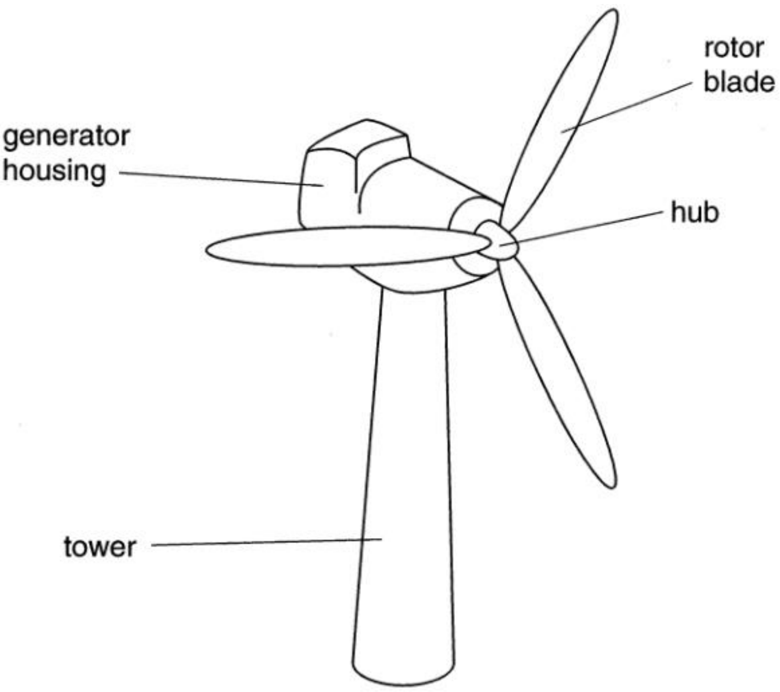


Fig. 8.1

The wind causes the rotor blades to turn and these drive an electric generator. The electric generator is situated in the housing at the top of the tower, as illustrated in Fig. 8.2.

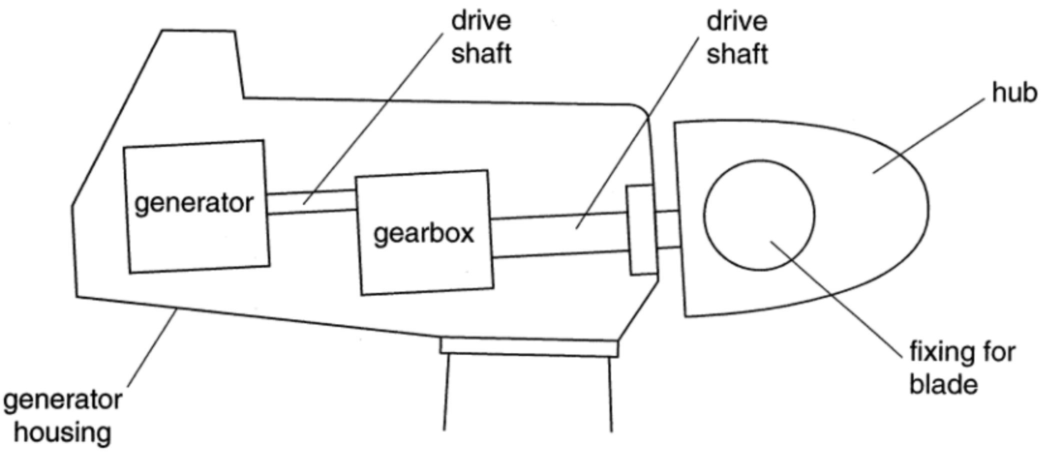


Fig. 8.2

Some information provide by a manufacturer of wind turbines are given in Fig. 8.3.

height of tower from ground to hub	56 m
rotor diameter	44 m
number of blades	3
nominal output	500 kW
voltage	690 V
frequency	50 Hz

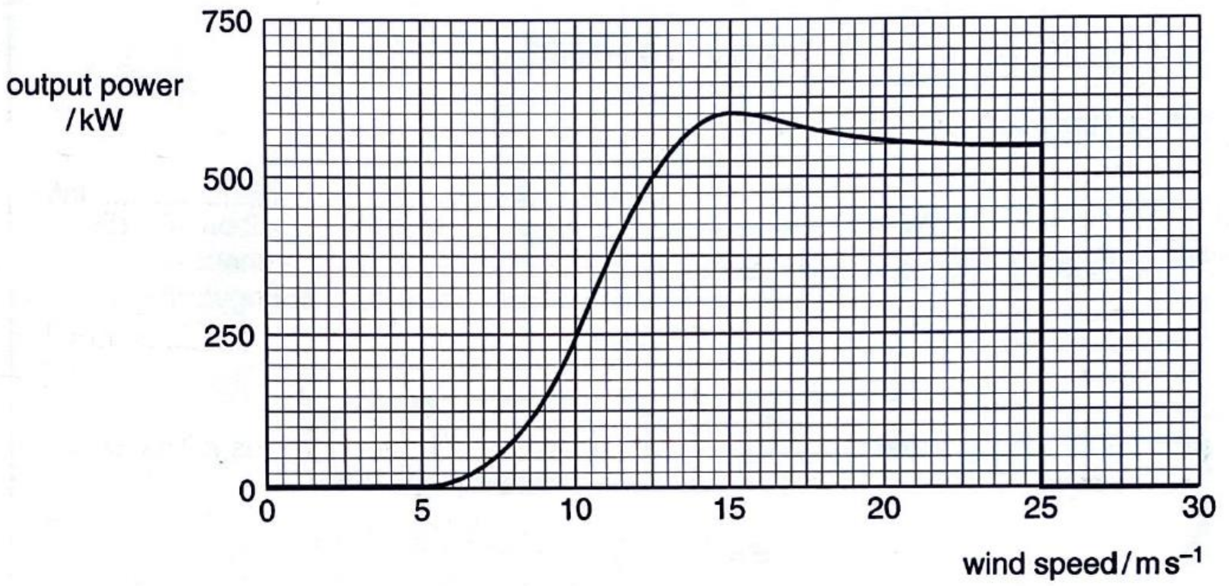


Fig. 8.3

One such wind turbine is built near a town. The local newspaper reported that the wind turbine 'could serve 200 homes'.

(a) Suggest one reason,

(i) why the manufacturer specifies a *nominal* output power for the wind turbine,

………………………………………………………………………………………………………..

………………………………………………………………………………………………………..

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

(ii) why the report that the wind turbine can serve 200 homes can be misleading.

………………………………………………………………………………………………………..

………………………………………………………………………………………………………..

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

(b) Determine the minimum height of the tip of a rotor blade above the ground level.

height = ………………………………… m [1]

(c) **(i)** Use the manufacturer's data to give values of

1. the maximum power output,

maximum power = ……………………………….. kW [1]

2. the wind speed for this maximum power.

wind speed = …………………………….. m s^{-1} [1]

(ii) Air of density ρ and speed v is incident normally on a rotor of radius r. The kinetic energy E of the air incident on the rotor in unit time is given by

$$E = \tfrac{1}{2}\pi r^2 v^3 \rho.$$

The air has density 1.25 kg m^{-3}.

Calculate, for the wind turbine operating at maximum output power,

1. the kinetic energy of air incident per second on the rotor (the incident wind power),

incident wind power = ……………..…………………………….. W [2]

2. the overall efficiency of generation of electric power.

efficiency = …………………………………….. % [2]

(iii) In addition to the power usefully transformed in the wind turbine, 10% of the incident wind power is lost. Calculate the power of wind after it has passed through the rotor.

power = ……………………….…………….. W [2]

(iv) At high wind speeds, the turbine is 'cut out', that is, the generator is no longer turned by the blades.

1. Use Fig. 8.3 to determine this cut-out speed.

cut-out speed = …………………………………….. m s^{-1} [1]

2. Suggest one reason why it is necessary to have a cut-out speed.

……………………………………………………………………………………………..

……………………………………………………………………………………………..

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

(d) **(i)** State whether the generator produces direct current or alternating current, explaining how you came to your conclusion.

……………………………………………………………………………………………..

……………………………………………………………………………………………..

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

(ii) Calculate the nominal current from the generator.

current = ……………..………………………... A [2]

(e) The wind turbine must be protected from lightning strike.

(i) Suggest, with reasons, which part of the wind turbine is most likely to be struck by lightning.

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

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

(ii) Suggest how the risk of damage by lightning may be minimised.

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

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

[Total: 20]

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