ATAR Course Examination, 2020

Question/Answer Booklet

PHYSICS

Name:____

Teacher:_______________________________________

Time allowed for this paper

Reading time before commencing work:	ten minutes
Working time for paper:	three hours

Material required/recommended for this paper

To be provided by the supervisor

This Question/Answer booklet
Formula and Data booklet

To be provided by the candidate

Standard Items:	pens (blue/black preferred), pencils (including coloured), sharpener, correction fluid/tape, eraser, ruler, highlighters
Special Items:	non-programmable calculators satisfying the conditions set by the School Curriculum and Standards Authority for this course, drawing templates, drawing compass and a protractor

Important note to candidates

No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

Structure of this paper

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of examination
Section One Short response	11	11	50	57	30
Section Two Problem-solving	7	7	90	94	50
Section Three Comprehension	2	2	40	38	20
			Total	**189**	**100**

Instructions to candidates

1. The rules for the conduct of Western Australian external examinations are detailed in the *Year 12 Information Handbook 2020.* Sitting this examination implies that you agree to abide by these rules.

2. Write answers in this Question/Answer Booklet.

3. When calculating or estimating answers, show all your working clearly. Your working should be in sufficient detail to allow your answers to be checked readily and for marks to be awarded for reasoning.

   In calculations, give final answers to three significant figures and include appropriate units where applicable.

   In estimates, give final answers to a maximum of two significant figures and include appropriate units where applicable.

4. You must be careful to confine your responses to the specific questions asked and to follow any instructions that are specific to a particular question.

5. Supplementary pages for the use of planning/continuing your answer to a question have been provided at the end of this Question/Answer booklet. If you use these pages to continue an answer, indicate at the original answer where the answer is continued, i.e. give the page number.

6. The Formulae and Data booklet is not to be handed in with your Question/Answer booklet.

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SECTION ONE: Short Response 30% (57 marks)

This section has **11** questions. Answer **all** questions. Write your answers in the spaces provided.

When calculating numerical answers, show your working or reasoning clearly. Give final answers to **three** significant figures and include appropriate units where applicable.

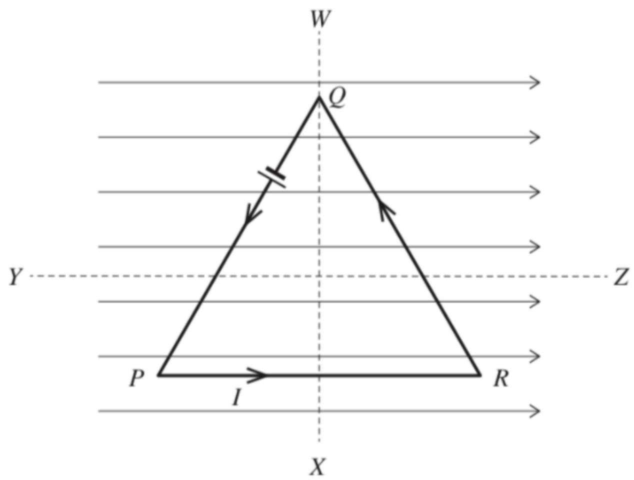
When estimating numerical answers, show your working or reasoning clearly. Give final answers to a maximum of **two** significant figures and include appropriate units where applicable.

Supplementary pages for the use of planning/continuing your answer to a question have been provided at the end of this Question/Answer booklet. If you use these pages to continue an answer, indicate at the original answer where the answer is continued, i.e. give the page number.

Suggested working time: 50 minutes.

Question 1 **(4 marks)**

A triangular piece of wire is paced in a uniform magnetic field as shown below. A current (I) flows through the triangular piece of wire as shown.



Complete the following table by labelling the statements as true (T) or false (F).

Statement	True (T) or False (F)
The triangle rotates about axis WX	
There is zero net force on the triangle	
PR provides more torque than RQ	
P is moving out of the page	

Question 2 **(4 marks)**

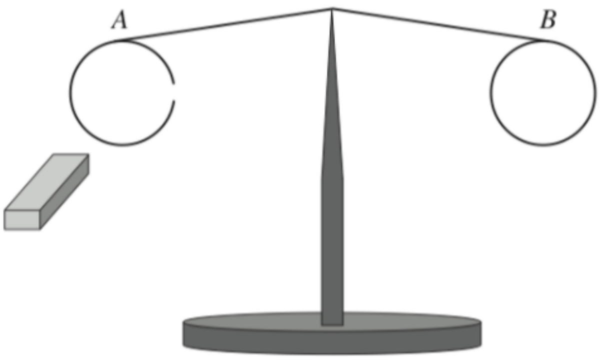
Experiments on the photoelectric effect show that:

- the kinetic energy of photoelectrons released depends upon the frequency of the incident light and not on its intensity
- light below a certain threshold frequency cannot release photoelectrons

How do these conclusions support a particle theory but not a wave theory of light?

Question 3 **(4 marks)**

The diagram below shows two rings A and B that are connected to a balancing arm which swings freely on a pivot. Ring A has a split in it.



A student pushes a bar magnet into ring A and then into ring B. State what she would observe in each part of the experiment and explain the observations, using relevant Physics.

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Question 4 **(5 marks)**

An exoplanet (one not from our solar system) orbits the star Pollux. Its mean orbital radius is 1.64 astronomical units (AU). The planet takes exactly 592 Earth days to orbit the star.

(a) Explain why the mass of the planet is not relevant when determining the mass of Pollux. (1 mark)

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(b) Calculate the mass of Pollux. (4 marks)

Answer: ___________ kg

Question 5 **(5 marks)**

An electron is travelling at 0.990 c.

(a) Calculate the rest energy of the electron. (2 marks)

_____________ J

(b) Calculate the relativistic kinetic energy of the electron. (2 marks)

____________ J

(c) If this question was about a positron, instead of an electron, in what way would your answer for (b) differ? (1 mark)

____

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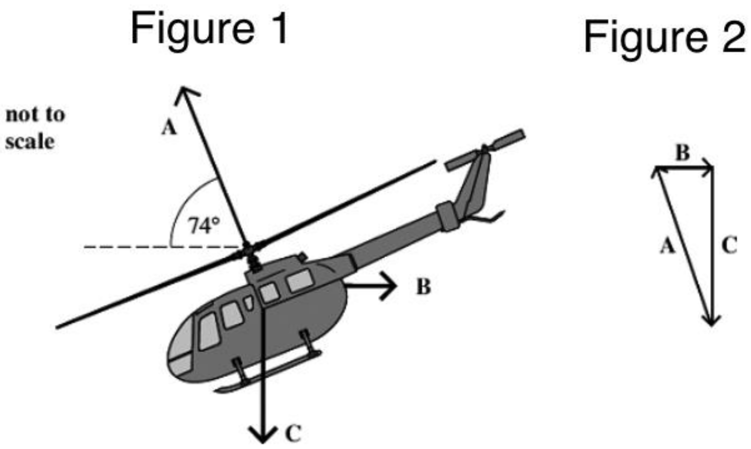
Question 6 **(4 marks)**

The helicopter shown in Figure 1 is flying horizontally at a constant velocity. Force **A** is the lift force provided by the helicopter's blades.



(a) Name the other two forces acting on the helicopter. (2 marks)

B: ______________________

C: ______________________

(b) The force vectors are shown in a triangle in Figure 2. State and explain how Figure 2 shows that the helicopter is flying at a constant velocity. (2 marks)

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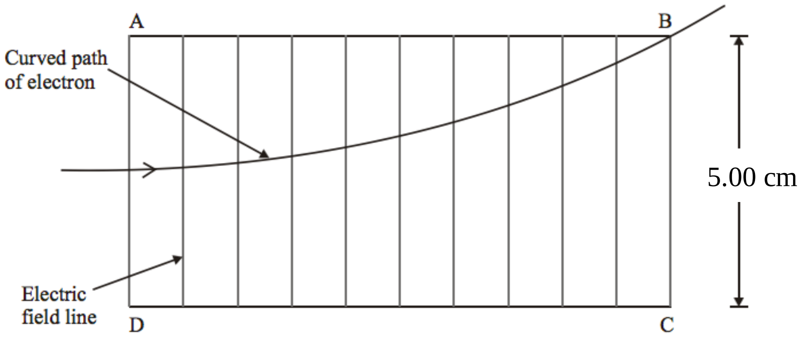
Question 7 **(7 marks)**

The diagram shows the path of an electron in a uniform electric field between two parallel conducting plates AB and CD. The electron enters the field at a point midway between A and D.

It leaves the field at B.



(a) Mark on the diagram the direction of the electric field lines. (1 mark)

(b) The conducting plates are 5.00 cm apart and have a potential difference of 255 V between them. Calculate the force on the electron due to the electric field. (3 marks)

Answer: __________ N

(c) State the direction of this force on the electron and explain why it does not affect the horizontal velocity of the electron. (3 marks)

____

____

____

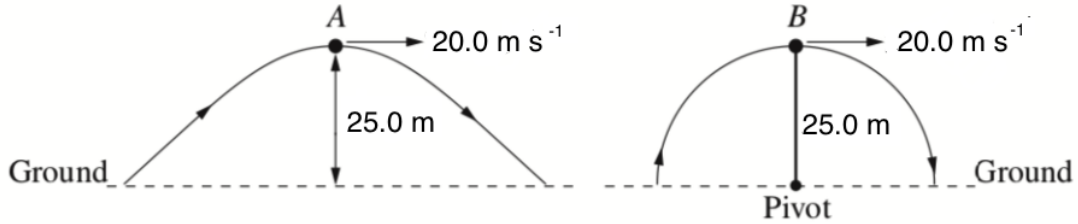
____

Question 8 **(6 marks)**

A 35.0 kg projectile, *A,* was fired from a cannon. When the projectile was at its maximum height of 25.0 m, it had a horizontal speed of 20.0 m s^{-1}.

An identical object, *B*, was attached to a mechanical arm and moved at a constant speed of 20.0 m s^{-1}. Its path was a vertical semicircle. The arm's length was 25.0 m.

Air resistance is negligible.



(a) For objects *A* and *B*, show the direction of the net force at the positions shown with arrows. (2 marks)

(b) Calculate the vertical force, *F*, that the mechanical arm is exerting on object *B* at the position shown. (4 marks)

F = ________ N

Question 9 **(3 marks)**

According to Einstein's Theory of Special Relativity, the speed of an object cannot be greater than or equal to the speed of light. However, its kinetic energy can be increased without limit. Explain the apparent contradiction that the speed of an object is limited whereas its kinetic energy is not limited.

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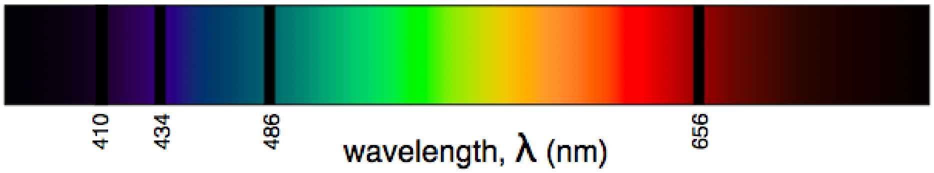
Question 10 **(8 marks)**

The figure below shows the absorption spectrum of hydrogen.



(a) Explain the origin of the dark lines shown in the absorption spectrum. (2 marks)

The absorption lines of hydrogen in the spectra of almost all galaxies show a *red shift*.

(b) Explain what is meant by a *red shift*. (2 marks)

(c) Explain what causes *red shift* and why observed *red shift* of distance galaxies provides evidence of the Big Bang Theory. (2 marks)

(d) Our closest galaxy is the Andromeda Galaxy (pictured). The hydrogen spectrum of Andromeda is observed to have a *blue shift*. Explain this observation and why this observation does not necessarily dispute the Big Bang Theory. (2 marks)

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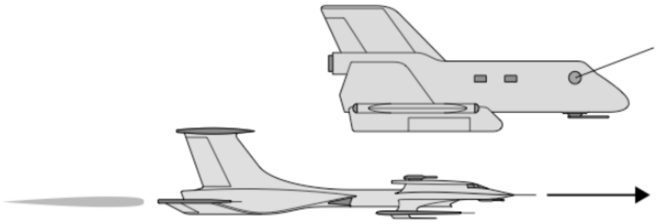
Question 11 **(7 marks)**

Spaceship *Endeavour* is stationary and has a circular window. Hamish is aboard Endeavour and measures the window to have a diameter of 2.00 m.

Eloise is aboard *Odyssey* which moves past *Endeavour* at a relative speed of 0.950 c.



(a) Describe the dimensions of the window according to Eloise. (4 marks)

Height of window: _____________ m

Width of window: ______________ m

(b) At the moment Odyssey is next to Endeavour, Eloise fires a rocket forwards at a velocity of 0.3 c, relative to Odyssey. Calculate the velocity of the rocket according to Hamish, who is onboard Endeavor. (3 marks)

_____________ c

End of Section One

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SECTION TWO: Problem-solving **50% (94 marks)**

This section has **six** questions. Answer **all** questions. Write your answers in the spaces provided.

When calculating numerical answers, show your working or reasoning clearly. Give final answers to **three** significant figures and include appropriate units where applicable.

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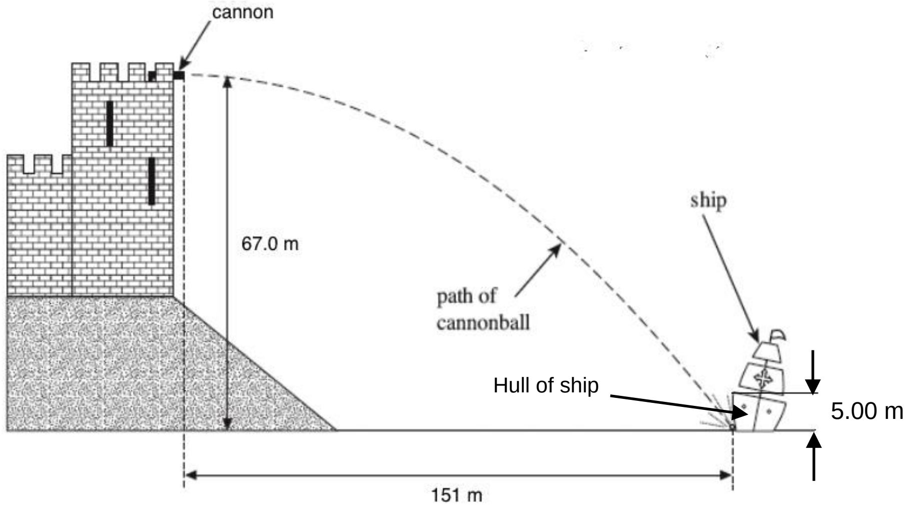
Suggested working time: 90 minutes.

Question 12 **(13 marks)**

A cannon is fired horizontally from a castle from a point 67.0 m above the water. The target is a tall ship, 151 m horizontally from the cannon as shown in the diagram. The ship's hull extends 5.00 m above the waterline. The cannon fires a cannonball and it strikes the ship on the waterline as shown.



(a) Show that the time it took the cannonball to strike the ship was approximately 3.7 s. (2 marks)

(b) Show that the initial velocity of the cannonball was approximately 40 m s^{-1}. (2 marks)

(c) Fully describe the velocity of the cannonball at the moment it strikes the ship's hull. (5 marks)

Velocity: _____________ m s^{-1}

Angle below horizontal _____ °

(d) The cannon was then tilted, so that the cannonball was fired at the same velocity, at an angle of 11° above the horizontal. Did the cannon ball still strike the hull of the ship? Support your answer with suitable calculations. (4 marks)

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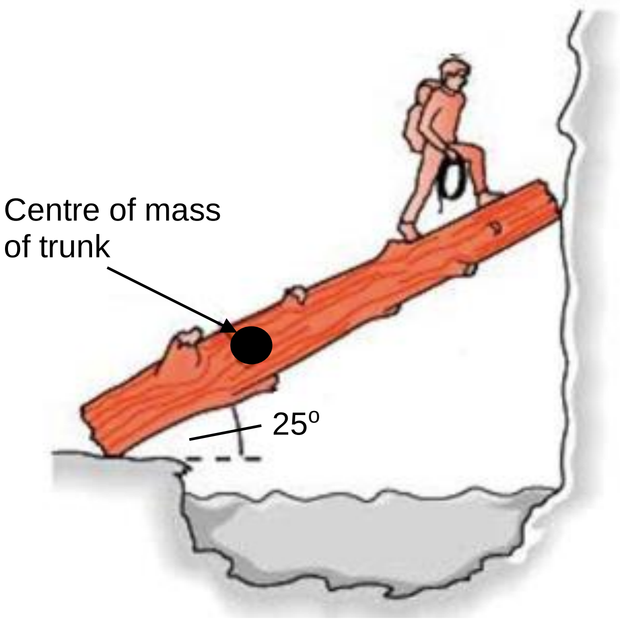
Question 13 **(10 marks)**

Andrew has a mass of 70.0 kg and he is climbing along a 325 kg tree trunk that is inclined at 25° to the horizontal. The trunk has a length of 5.00 m and its centre of mass is 2.00 m from the base of the trunk. There is no friction between the trunk and the vertical wall. The maximum horizontal force of friction provided by the ground to the base of the trunk is 80% of the vertical force provided by the ground (i.e. the coefficient of friction is 0.8).



(a) On the diagram above, show as labelled arrows, all forces acting on the trunk. (3 marks)

(b) Calculate the vertical force exerted by the ground on the trunk at its base and hence the maximum friction that can be provided by the ground to the base of the trunk. (2 marks)

Vertical force: ______________ N

Maximum friction: ___________N

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(c) Can Andrew climb all of the way to the end of the trunk without the base slipping? Use suitable calculations to support your answer. (5 marks)

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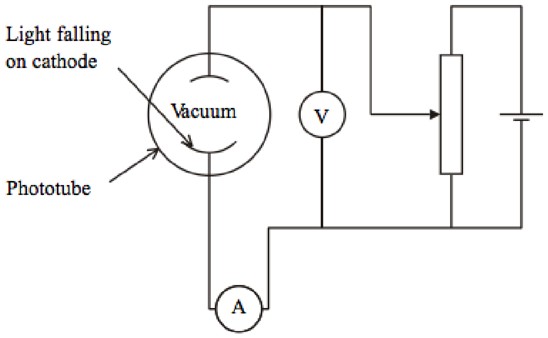
Question 14 **(16 marks)**

Heinrich Hertz first observed the photoelectric effect in 1887. He detected a current when light fell on a metal surface. In later research scientists measured the work function W of several metals.

(a) Explain the term *work function*. (2 marks)

To measure the work function, the scientists used a phototube, consisting of a metal cathode and anode in an evacuated tube. Light falling on the cathode produced a current in the circuit.



(b) Explain how this current is produced. Use the terms *photon* and *photoelectron* in your explanation. (2 marks)

(c) State the effect on the released photoelectrons of an increase in: (2 marks)

(i) the intensity of the light used

(ii) the frequency of the light used

(d) Light of wavelength 4.2×10^{-7} m is shone onto the metal cathode. Calculate the energy of these photons. (2 marks)

__________ eV

(e) The metal is sodium, with a work function of 2.7 eV. Calculate the maximum kinetic energy in eV that a photoelectron could gain from this photon. (1 mark)

__________ eV

(f) When the potential difference between the cathode and anode was reversed the current was reduced.

(i) Explain this observation. (2 marks)

(ii) Calculate the potential difference required (stopping potential) for the current to be reduced to zero. (2 marks)

__________ V

(g) Does the photoelectric effect support a *wave* or particle theory of light. Explain. (3 marks)

Question 15 **(16 marks)**

In 1961 Murray Gell-Mann predicted the existence of a new particle called an omega (Ω) minus. It was subsequently discovered in 1964.

At this time the quark model consisted of three particles, the properties of which are given in the Formula and Data Booklet provided for this examination.

(a) Explain what is meant by a charge of $+2/3$. (1 mark)

___

(b) State the predicted mass and charge of the antiquark $\bar{s}$. (2 marks)

Charge: ________

Mass: _________

(c) Calculate the mass of a down quark in kg. (2 marks)

_____________ kg

(d) The event which led to the discovery of the omega minus particle can be summarised as follows. A negative kaon collided with a stationary proton and produced a positive kaon, a neutral kaon and the omega minus.

(i) Kaons (K) consist of combinations of *either* an up or down quark plus a strange quark. The omega minus consists of three strange quarks. Complete the following table by ticking the appropriate boxes. (4 marks)

	MESON	BARYON	NUCLEON	LEPTON
NEGATIVE KAON				
OMEGA MINUS				

(ii) Write an equation using standard particle symbols to summarise this event. (2 marks)

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(e) The negative kaon has a quark composition of $\bar{u}s$. Deduce the quark structure of the other two kaons involved in this event. (2 marks)

K^o ____________________

K^+ ____________________

(f) The total mass of the three particles created after this event is larger than the total mass of the two particles before. Discuss the quantities that must be conserved in interactions between particles and explain this increase in mass. (3 marks)

Question 16 **(12 marks)**

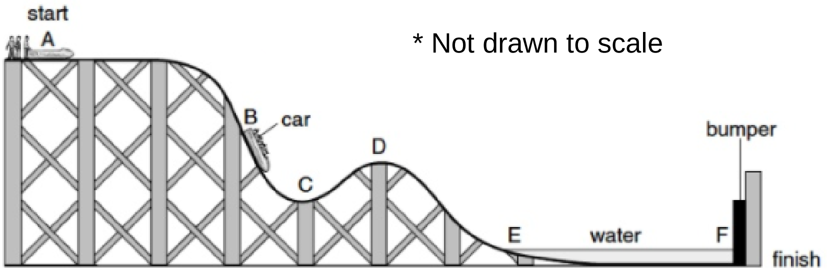
The diagram below shows various stages a rollercoaster ride.

Point A is the starting point of the ride and is 10.0 m above the ground. The rollercoaster has a speed of 0.250 m s^{-1} at this point.

Point C is 5.00 m above the ground and is circular with a radius of 5.0 m.

Point D is 6.00 m above the ground and is also circular with a radius of 5.0 m.

At point E, the rollercoaster enters a pool of water which slows down the rollercoaster. The distance between E and F is 12.0 m. The loaded rollercoaster has a mass of 1,530 kg.



As the rollercoaster moves from A to E, frictional forces are negligible.

(a) Calculate the speed of the rollercoaster at C. (2 marks)

________ m s^{-1}

(b) The figure below shows Gemma, who has a mass of 55.0 kg sitting in the rollercoaster at point C. Show all vertical forces acting on Gemma as labelled arrows on the diagram. (2 marks)

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(c) Gemma usually experience her weight (*mg*) when sitting in a chair. By what multiple of this weight does Gemma "feel" heavier or lighter at point C? (e.g. if she *feels* 80% of her usual weight, the multiple is 0.8). (3 marks)

_______________ lighter/heavier
(circle the correct word)

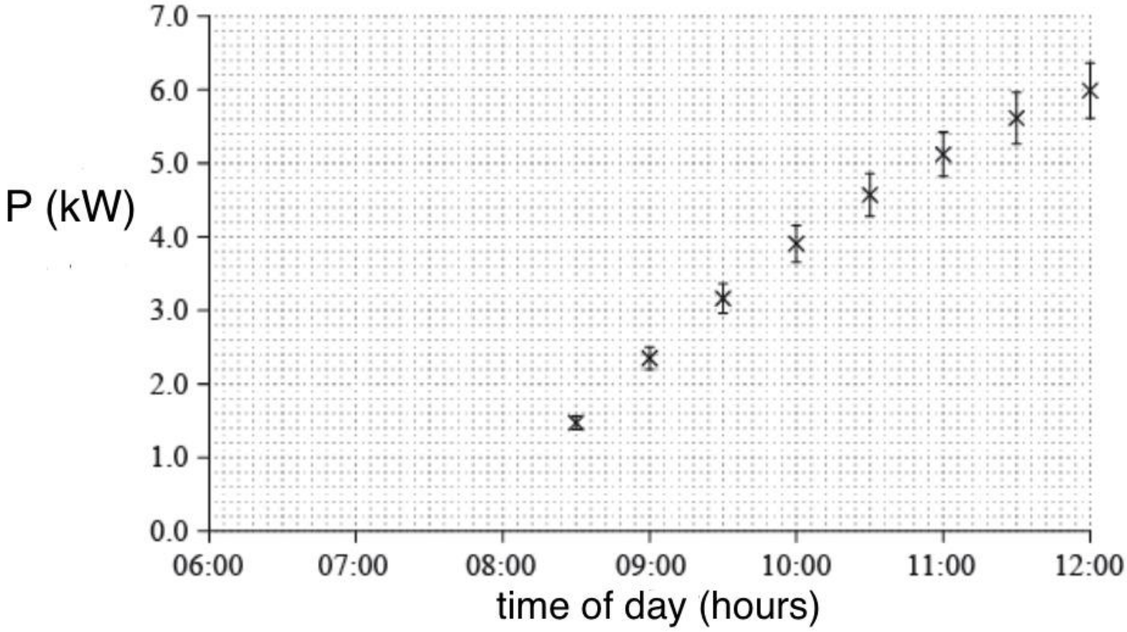
(d) Would Gemma need her seatbelt at point D to prevent her from lifting off her seat? Support your answer with an appropriate calculation. (3 marks)

(e) Calculate the average force of friction provided by the water, between points E and F, for the rollercoaster to come to rest before reaching point F. (2 marks)

Question 17 **(15 marks)**

An array of photovoltaic cells is used to provide electrical energy for a house. When the array produces more power than is consumed in the house, the excess power is fed back into the mains electrical supply for use by other consumers.

The graph below, shows how the power P produced by the array varies with the time of day. The error bars show the uncertainty in the power supplied. The uncertainty in the time is too small to be shown.



(a) Using the graph, estimate the time of day at which the array begins to generate energy. (2 marks)

Answer __________

(b) State the value the power produced by the array at 12:00. (2 marks)

P _______ kW

± _______ kW

(c) State the percentage uncertainty of the power produced by the array at 12:00. (2 marks)

________ %

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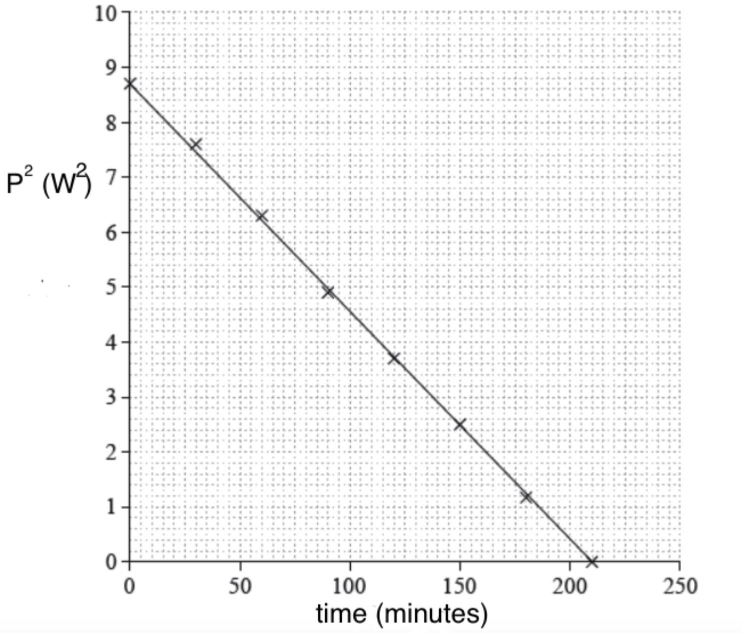
(d) The average power consumed by the house between 8:00 and 12:00 is 2.00 kW. Calculate the excess energy supplied by the array to the electricity grid in this time. Give your answer in MJ. Note: uncertainties are not required in this part of the question. (4 marks)

Answer ________ MJ

Later in the day as the sunlight becomes less, the power produced by the array decreases. The graph below shows how the square of power varies with time as the sunlight reduces.



(e) Using the graph, determine the relationship between P^2 and t. (3 marks)

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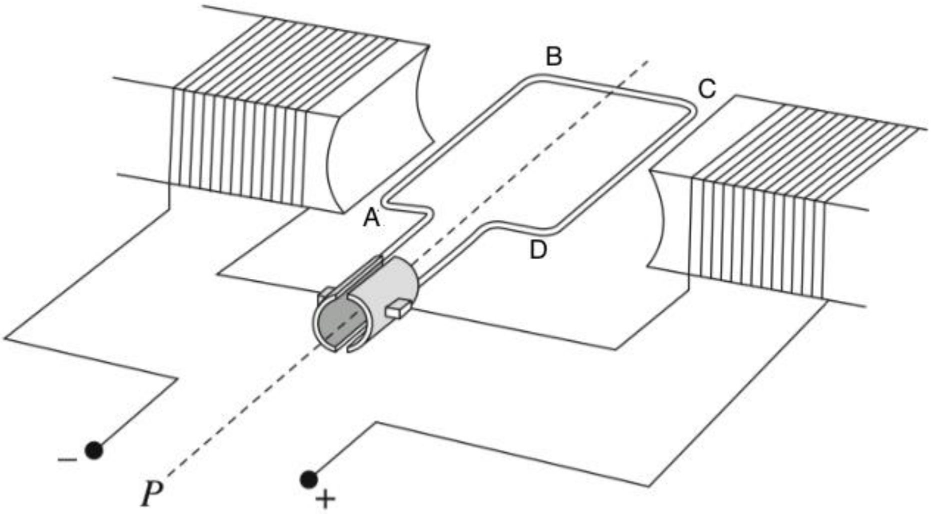
(f) Using your relationship from part (e), estimate the power output of the array, 50 minutes before the above data was collected. (2 marks)

Question 18 **(12 marks)**

The diagram below shows a simple electric motor.



(a) Is the electric motor designed to operate on an AC or a DC source? Explain. (2 marks)

___

___

(b) Show with arrows, the direction of the magnetic field surrounding the coil ABCD. (2 marks)

(c) As viewed from P, in what direction does the coil ABCD rotate? Circle the correct answer. (1 mark)

clockwise / anticlockwise

(d) The motor is rotating at a constant rate of one rotation per second. On the axes below, show:

(i) How the force on AB varies over for the first two seconds of rotation from the position shown. (Note: specific values on the force axis are not required). (2 marks)

(ii) How the torque on coil ABCD varies over for the first two seconds of rotation from the position shown. (Note: specific values on the torque axis are not required). (2 marks)

(e) Anil decides to remove the power supply and rotate coil ABCD to produce an emf. On the axes below, show how the emf produced varies with time. Explain any features of your sketched graph. (Note: specific values on the EMF axis are not required). (3 marks)

End of Section Two

SECTION THREE: Comprehension **20% (38 marks)**

This section has **two (2)** questions. You must answer **both** questions. Write your answers in the spaces provided.

When calculating numerical answers, show your working or reasoning clearly. Give final answers to **three** significant figures and include appropriate units where applicable.
When estimating numerical answers, show your working or reasoning clearly. Give final answers to a maximum of **two** significant figures and include appropriate units where applicable.

Additional working space pages at the end of this Question/Answer booklet are for planning or continuing an answer. If you use these pages, indicate at the original answer, the page number it is planned/continued on and write the question number being planned/continued on the additional working space page.

Suggested working time: 40 minutes.

Question 19 **(19 marks)**

Article adapted from *Muon colliders come a step closer*, Nature, February 5, 2020

Muon colliders come a step closer

Particle colliders that use elementary particles called muons could outperform conventional colliders, while requiring much smaller facilities. Muon cooling, a milestone on the road to these muon colliders, has now been achieved

Muons, like electrons, are elementary particles in the standard model of particle physics, but they have about 200 times the mass of electrons. This fact has ramifications for the size, and therefore cost, of colliders, and for the energy that can be reached in their particle collisions (and thus their potential for discovery).

Although the goal is to accelerate particles so that they collide at the highest possible energies, the particles actually lose energy through radiation when their trajectories are bent by accelerator magnets. Heavy particles such as protons and muons lose much less energy than lightweight particles such as electrons. For this reason, the circular colliders that can reach the highest energies (for example, the LHC) use protons. However, protons are not elementary particles. They are made up of elementary particles called quarks, and because the collisions are between bound quarks, only about one-sixth to one-tenth of the energy from proton collisions is available to produce other particles. By contrast, because muons are elementary particles, all of the energy from their collisions is available for particle production.

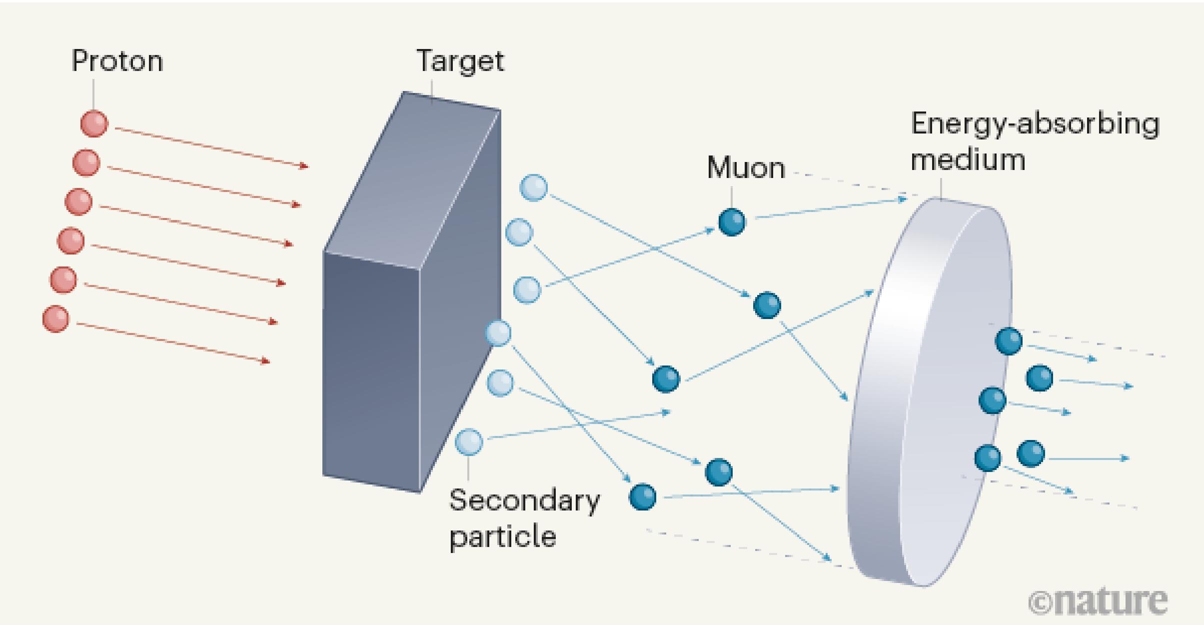
Muon accelerators would have uses beyond those for particle colliders. For example, a ‘Higgs factory’ is a highly desirable facility that would produce huge numbers of elementary particles known as Higgs bosons and allow the properties of these particles to be precisely determined. A Higgs factory based on a conventional linear accelerator that collides electrons and positrons (the antiparticles of electrons) would have to be 10–20 kilometres long. But one based on a circular muon collider would require a circumference of only about 0.3 km. In another example, if muons could be stored in a racetrack configuration that has long, straight sections, the decay of the muons in these sections would produce intense neutrino beams. Such a facility, called a neutrino factory, would shed light on the mysteries of neutrinos and on physics beyond the standard model.

Before a neutrino factory or a muon collider can exist, scientists must learn how to manipulate muon beams. Unlike electron beams, which are produced with almost laser-like quality, muon beams are generated through a complicated process resulting in a beam that is more reminiscent of the spray of pellets from a shotgun. This spray needs to be converted into a laser-like beam.

Such a conversion involves reducing the spread of the muons' positions and velocities in the directions perpendicular to the beam. A temperature can be associated with this spread, and cooling the beam decreases the spread. Several cooling techniques are used at accelerators, but none is fast enough to cool muons, which are unstable and short-lived.

Instead, a method called ionization cooling has been proposed for cooling muon beams, although it has never been used. In this approach, muons travel through an accelerator, a portion of which contains a material of low atomic mass, and the spread of the muons' positions and velocities is reduced as the particles ionize atomic electrons in the material. The MICE (Muon Ionization Cooling Experiment) collaboration's aim was to build and test a system for the ionization cooling of muons, to demonstrate this cooling for the first time and to validate simulation tools for the design of ionization-cooling systems.

In the authors' experiment, a proton beam from the ISIS accelerator at the Rutherford Appleton Laboratory near Didcot, UK, struck a target to produce secondary particles. Some of these particles decayed into muons, which were directed into an experimental apparatus consisting of focusing magnets, beam instrumentation and a cooling section that contained an energy-absorbing medium made of lithium hydride or liquid hydrogen.



Production and ionization cooling of muons. The MICE collaboration[1] carried out an experiment in which a beam of protons was directed at a target to generate secondary particles. Some of these particles decayed into elementary particles known as muons. The positions and velocities of the muons in the resulting in a widespread beam. The muons are then passed through an energy-absorbing medium made of lithium hydride or liquid hydrogen that reduced this spread by a process called ionization cooling. The process demonstrated by the authors could someday lead to a muon-based particle accelerator.

(a) Explain why it is preferential to use protons or muons in particle accelerators compared to electrons. (2 marks)

(b) Explain the advantages associated with colliding muons compared with protons in particle accelerators. (2 marks)

(c) The article states that muon collision would be a superior method than electron/positron collision for large scale production of Higgs bosons. What is the practical advantage of using muon collisions and explain the Physics of how muon collisions would give rise to more Higgs bosons, compared with electron/positron collisions. (3 marks)

(d) Explain why it is necessary to cool the beam of muons prior to colliding them. (1 mark)

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(e) The article mentions “focusing magnets”. Explain how magnets could be used to focus a beam of muons. (2 marks)

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(f) A particular linear accelerator has a length of 5.00 km. Calculate the potential difference requires to accelerate an electron to a speed of 0.1 c. You may ignore any relativistic effects. (3 marks)

____________ V

(g) Muons are highly unstable and have a typical half-life of 2.2 μs. In a future particle accelerator, muons are accelerated to speeds of 0.995 c.

(i) Calculate the half-life a muon travelling at this speed, in the reference frame of the observers at the particle accelerator. (3 marks)

__________ μs.

(ii) Calculate the kinetic energy of these muons, in the reference frame of observers at the particle accelerator. (3 marks)

_____________ MeV

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Question 20 **(19 marks)**

(article adapted from: Homer, D, and Bowen-Jones, M, Physics course companion for the IB Diploma. Oxford University Press, 2015)

Luminosity and apparent brightness of stars

For any point source, the intensity of a wave varies with the inverse square of the distance from that source.

$$I = \frac{P}{4\pi r^2}$$

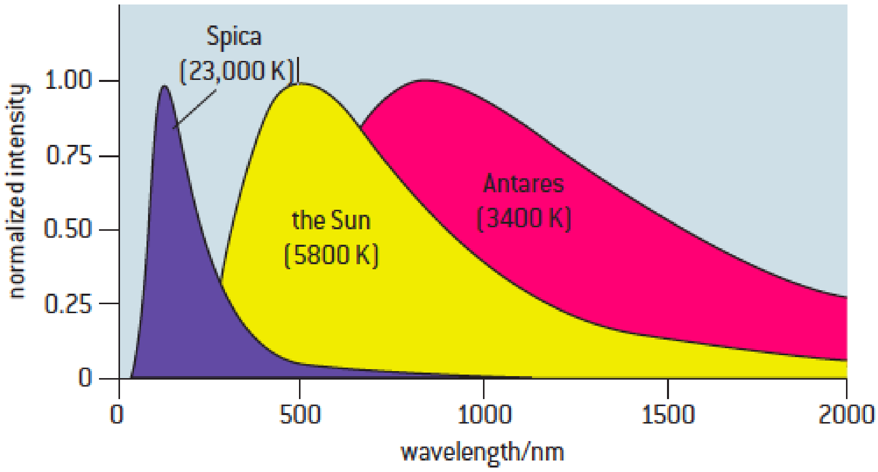
For stars, P is called the luminosity (L) and represents the total power emitted by the star in watt (W). I in this context is the apparent brightness (*b*) and is measured in watts per square metre (Wm^{-2}). The distance from the star is usually denoted by *d*. This version of the equation is usually written as:

$$b = \frac{L}{4\pi d^2}$$

Black Bodies

Black bodies are theoretical objects that absorb all the radiation that is incident upon them. Because there is no reflection or re-emission, they appear completely black – as their name suggests. Such bodies would also behave as perfect emitters of radiation, emitting the maximum amount of radiation possible at their temperature.

All objects at temperatures above absolute zero emit black-body radiation. This type of radiation consists of every wavelength possible but containing different amounts of energy at each wavelength for a particular temperature. Although stars are not perfect black-bodies they are capable of emitting and absorbing all wavelengths of electromagnetic radiation. The figure below shows the black-body radiation curves for the Sun, the very hot star Spica, and the cold star Antares. Because each of the stars will produce different intensities, the curves have been normalized by dividing the intensity emitted at a given wavelength by the maximum intensity that the star yields – this means the vertical scale has no unit and the maximum value it can take is 1.00. The maximum intensity of radiation emitted by the Sun has a wavelength of just over 500 nm making it appear yellow; the peak intensity for Spica is in the ultraviolet region, but there is sufficient intensity in the blue region for it to appear blue; the peak for Antares is in the near infra-red but, with plenty of red light emitted, it appears to be red to the naked eye.



For a star the Stefan–Boltzmann law is written as:

$$L = \sigma A T^4$$

where L is the luminosity in watts, A the surface area of the star in square metres, and T the temperature in kelvin. σ is the Stefan–Boltzmann constant = 5.67×10^{-8} Wm $^{-2}$ K $^{-4}$.

When we assume that a star is spherical we can use this equation in the form:

$$L = \sigma 4 \pi R^2 T^4$$, where R is the radius of the star.

We can see that the luminosity of a star depends on its temperature and its size (measured here by its surface area).

(a) Explain why black bodies are called “black bodies”. (2 marks)

(b) In terms of photon energy, why do hotter stars emit shorter wavelength light? (3 marks)

(c) Explain why all three stars in the figure have the same maximum intensity. (2 marks)

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(d) Using information from the article and data from the Formula and Data booklet, show that the luminosity of the Sun is approximately 3.8 x 10^{26} W m^{-2}. (4 marks)

Calculated Luminosity ___________ W m^{-2}

(e) Some data for the variable star Betelgeuse are given below.

Average apparent brightness = 1.6 x 10^{-7} Wm^{-2}

Radius = 79 solar radii

Earth – Betelgeuse distance = 1.38 x 10^{-4} Mpc

(i) Calculate the distance between the Earth and Betelgeuse in metres. (2 marks)

__________ m

(ii) Calculate the luminosity of Betelgeuse. (3 marks)

__________ Wm^{-2}

(iii) Calculate the surface temperature of Betelgeuse. (3 marks)

_________ K

End of questions

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