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Government of South Australia

SACE Board of SA | South Australian Certificate of Education

Physics
November 2018 sample paper

Question Booklet 1

- Questions 1 to 11 (63 marks)
- Answer ***all*** questions
- Write your answers in this question booklet
- You may write on page 18 if you need more space
- Allow approximately 60 minutes

Examination information

Materials
- Question Booklet 1
- Question Booklet 2
- SACE registration number label

Reading time
- 10 minutes

Writing time
- 2 hours
- Clear well-expressed answers are required
- Use black or blue pen
- You may use a sharp dark pencil for diagrams
- Approved calculators may be used

Total marks 120

Attach your SACE registration number label here

For office use only

Supervisor check	Re-marked

This sample Physics paper shows the format of the examination for November 2018.

You may remove this page from the booklet by tearing along the perforations.

FORMULA SHEET

Vectors are indicated by arrows. If only the magnitude of a vector quantity is used, the arrow is not used.

Symbols of common quantities

acceleration	$\vec{a}$	frequency	f	momentum	$\vec{p}$
charge	q	kinetic energy	E_K	period	T
displacement	$\vec{s}$	length	l	potential difference	ΔV
electric current	I	magnetic field	$\vec{B}$	time	t
electromotive force	emf	magnetic flux	Φ	velocity	$\vec{v}$
force	$\vec{F}$	mass	m	wavelength	λ

Magnitude of physical constants

Acceleration due to gravity at the Earth's surface	$g = 9.80\ \text{m s}^{-2}$	Planck's constant	$h = 6.63 \times 10^{-34}\ \text{J s}$
Constant of universal gravitation	$G = 6.67 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2}$	Charge of the electron	$e = 1.60 \times 10^{-19}\ \text{C}$
Speed of light in a vacuum	$c = 3.00 \times 10^{8}\ \text{m s}^{-1}$	Mass of the electron	$m_e = 9.11 \times 10^{-31}\ \text{kg}$
Coulomb's law constant	$\frac{1}{4\pi\varepsilon_0} = 9.00 \times 10^{9}\ \text{N m}^2\ \text{C}^{-2}$	Mass of the proton	$m_p = 1.673 \times 10^{-27}\ \text{kg}$
Constant for the magnetic field around a conductor	$\frac{\mu_0}{2\pi} = 2.00 \times 10^{-7}\ \text{N m A}^{-1}$		

Topic 1: Motion and relativity

$\vec{v} = \vec{v}_0 + \vec{a}t$	$\vec{v}$ = velocity at time t $\vec{v}_0$ = velocity at time 0	$v = \frac{2\pi r}{T}$	
$\vec{s} = \vec{v}_0 t + \frac{1}{2}\vec{a}t^2$		$\vec{g} = \frac{\vec{F}}{m}$	$\vec{g}$ = gravitational field strength
$v^2 = v_0^2 + 2as$		$F = G\frac{m_1 m_2}{r^2}$	r = distance between masses m_1 and m_2
$v_H = v\cos\theta$ $v_V = v\sin\theta$	θ = angle to horizontal	$v = \sqrt{\frac{GM}{r}}$	M = mass of object orbited by satellite r = radius of orbit
$\vec{a} = \frac{\Delta\vec{v}}{\Delta t}$		$T^2 = \frac{4\pi^2}{GM}r^3$	
$\vec{F} = m\vec{a}$		$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$	γ = Lorentz factor
$\vec{F} = \frac{\Delta\vec{p}}{\Delta t}$		$t = \gamma t_0$	t_0 = time interval in the moving frame of reference
$\vec{p} = m\vec{v}$		$l = \frac{l_0}{\gamma}$	l_0 = length in the moving object's frame of reference
$a = \frac{v^2}{r}$	r = radius of circle	$p = \gamma m_0 v$	m_0 = mass in the frame of reference where the object is stationary

This sample Physics paper shows the format of the examination for November 2018.

Topic 2: Electricity and magnetism

$F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$	r = distance between charges q_1 and q_2	$F = qvB\sin\theta$	θ = angle between field $\vec{B}$ and velocity $\vec{v}$
$\vec{E} = \frac{\vec{F}}{q}$	$\vec{E}$ = electric field	$r = \frac{mv}{qB}$	r = radius of circle
$E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$	r = distance from charge	$T = \frac{2\pi m}{qB}$	
$W = q\Delta V$	W = work done	$E_K = \frac{q^2 B^2 r^2}{2m}$	r = radius at which ions emerge from cyclotron
$E = \frac{\Delta V}{d}$	d = distance between parallel plates	$\Phi = BA_\perp$	$A_\perp$ = area perpendicular to the magnetic field
$\vec{a} = \frac{q\vec{E}}{m}$		$emf = \frac{\Delta\Phi}{\Delta t}$	
$B = \frac{\mu_0}{2\pi}\frac{I}{r}$	r = distance from conductor	$\frac{V_p}{V_s} = \frac{n_p}{n_s}$	V = potential difference in transformer coils
$F = IlB\sin\theta$	θ = angle between field $\vec{B}$ and current element $I\vec{l}$		

Topic 3: Light and atoms

$d\sin\theta = m\lambda$	d = distance between slits θ = angular position of mth maximum m = integer $(0, 1, 2, \ldots)$	$E_{K\,\max} = eV_s$	$E_{K\,\max}$ = maximum kinetic energy of electrons V_s = stopping voltage
$\Delta y = \frac{\lambda L}{d}$	Δy = distance between adjacent minima or maxima L = slit-to-screen distance	$E_{K\,\max} = hf - W$	
$E = hf$	E = energy of photon	$f_{\max} = \frac{e\Delta V}{h}$	ΔV = potential difference across the X-ray tube
$p = \frac{h}{\lambda}$		$E = \Delta mc^2$	E = energy
$W = hf_0$	W = work function of the metal f_0 = threshold frequency		

TABLE OF PREFIXES

Prefix	Symbol	Value
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}

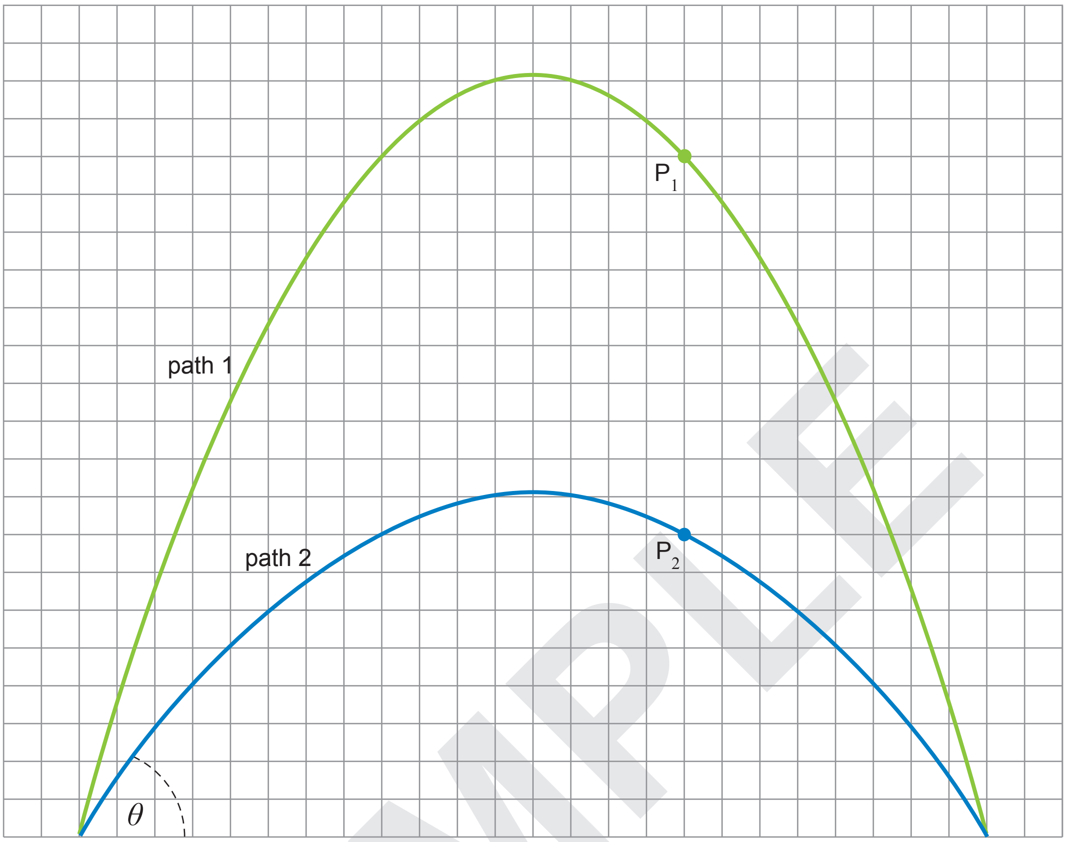
QUARKS

Quark	Symbol	Charge (e)
Up	u	$\frac{2}{3}$
Down	d	$-\frac{1}{3}$
Strange	s	$-\frac{1}{3}$
Charm	c	$\frac{2}{3}$
Top	t	$\frac{2}{3}$
Bottom	b	$-\frac{1}{3}$

1. The diagram below shows the paths of two projectiles that experience negligible air resistance.

Path 1 shows the path of a projectile that was launched with an initial speed of $21\ \mathrm{m\,s^{-1}}$ at an angle of 55° above the horizontal.

Path 2 shows the path of a projectile that was launched with an initial speed of $21\ \mathrm{m\,s^{-1}}$ at an angle of θ above the horizontal.



(a) *On the diagram above*, draw vectors to show the direction and magnitude of the acceleration of each projectile at points P_1 and P_2. (2 marks)

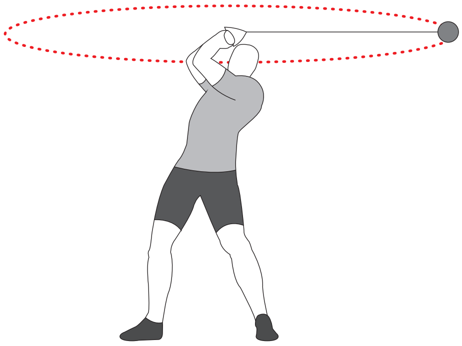
(b) State the size of angle θ.

____ (1 mark)

2. A hammer thrower rotates a heavy ball attached to a wire in a horizontal path with uniform circular motion.

The ball is swung at a speed of 20.0 m s^{-1}.

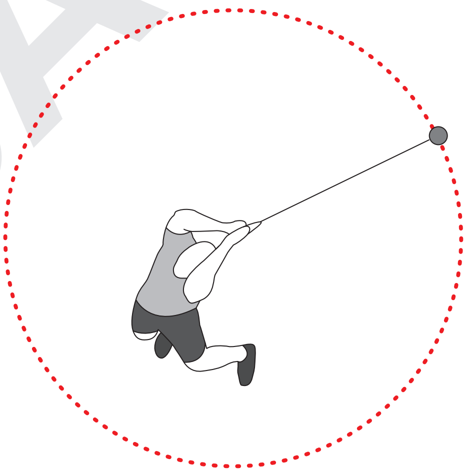
The ball has a mass of 7.26 kg and rotates at a radius of 1.25 m.



(a) Determine the magnitude of the force that causes the centripetal acceleration of the ball.

(3 marks)

(b) The diagram below shows a hammer thrower seen from above:



On the diagram above, draw and label vectors to show the net force on the ball as it is swung.

(1 mark)

3. Satellites in geostationary orbits are often used for monitoring weather. Australia receives weather information from Multi-functional Transport Satellites (MTSAT).

An MTSAT satellite has a mass of $2905\ \mathrm{kg}$, and it orbits the Earth at a radius of $4.216\times10^{7}\ \mathrm{m}$.

(a) Calculate the magnitude of the gravitational force that the Earth exerts on the satellite. The mass of the Earth is $5.972\times10^{24}\ \mathrm{kg}$.

(2 marks)

(b) Calculate the speed of the satellite.

(2 marks)

4. Two different objects were dropped from the top of a tall building at the same time, but each object reached the ground at a different time from the other.

Identify one reason why each object reached the ground at a different time. Justify your answer.

(3 marks)

5. In a flight archery competition the aim is to shoot the arrow as far as possible.

During such a competition, an arrow is shot with an initial speed of 43.4 m s^{-1}, at an angle of $38.0°$ above the horizontal. The arrow hits a tree at the same height from which it was shot.

Ignore air resistance in this question.

Source: © iStockphoto.com | subman

Determine the horizontal distance travelled by the arrow.

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____ (5 marks)

6. (a) When an electron is placed at a distance of 2.0×10^{-9} m from a point charge, q, it experiences a repulsive force of 1.7×10^{-10} N.

Determine the magnitude and sign of q.

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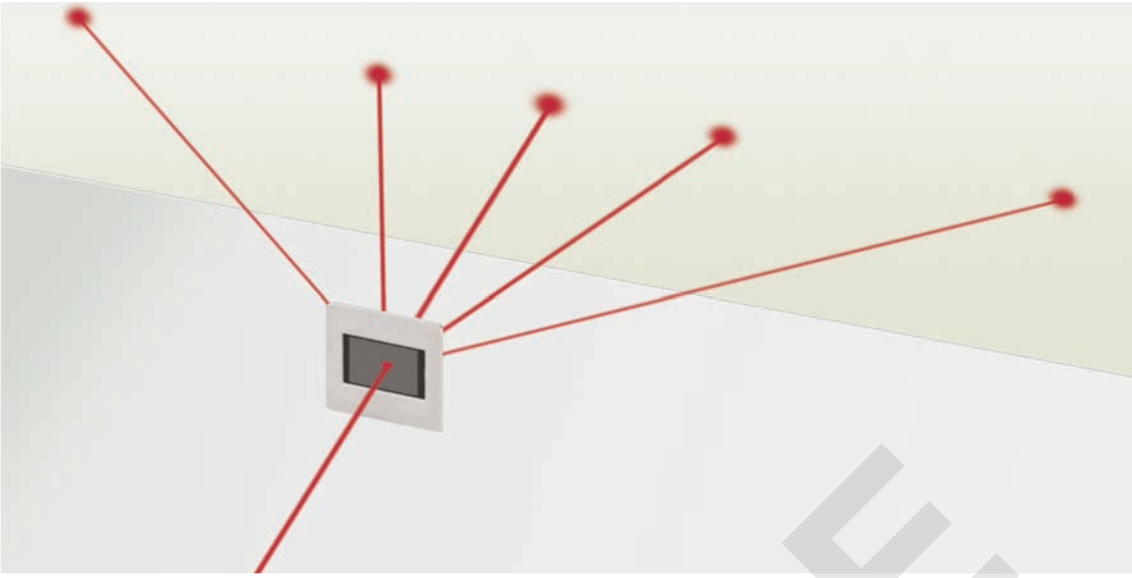
(b) The diagram below shows a negatively charged hollow spherical conductor:

On the diagram above, sketch the electric field lines produced by the negatively charged conductor. (2 marks)

7. In an experiment, red laser light with a wavelength of 6.50×10^{-7} m was directed normally at a transmission diffraction grating, as shown in the image below. A first-order maximum was recorded at an angle of $32°$.



(a) Show that the distance between the slits in the diffraction grating is 1.23×10^{-6} m.

(2 marks)

(b) The same diffraction grating was used in a second experiment. A different laser, which produces blue light, was used in this experiment.

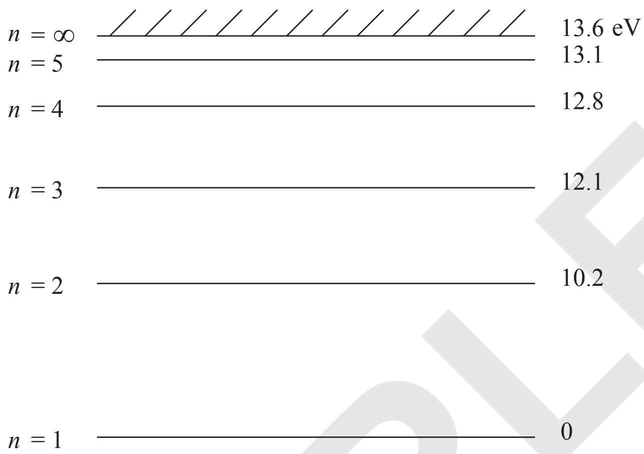
Explain *one* similarity and *one* difference between the patterns produced by the red lasers and the patterns produced by the blue lasers.

(3 marks)

8. (a) Show that the energy of photons with a wavelength of $478\ \text{nm}$ is $2.6\ \text{eV}$.

(2 marks)

(b) The diagram below shows some of the energy levels of hydrogen:



(i) *On the diagram above*, draw and label the transition within hydrogen atoms that would result from the *absorption* of photons with a wavelength of $478\ \text{nm}$. (1 mark)

(ii) State whether or not a line corresponding to photons with a wavelength of $478\ \text{nm}$ would occur in the absorption spectra of hydrogen at room temperature. Justify your answer.

(2 marks)

9. The photograph below shows a scanning electron microscope:

Source: http://caf.ua.edu

The electrons in the electron microscope gain energy as they move through a potential difference of $10\ \text{kV}$.

(a) Show that the electrons are accelerated to a speed of $5.9 \times 10^7\ \text{m s}^{-1}$.

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____ (4 marks)

(b) Calculate the wavelength of electrons travelling at a speed of $5.9 \times 10^7\ \text{m s}^{-1}$.

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____ (2 marks)

10. A transformer is used to change the potential difference and the current in an alternating current power supply. A high potential difference is used when transmitting electrical energy in power lines, and a lower potential difference is needed when this energy reaches a home.

(a) A transformer containing a primary coil with 1625 turns is used to decrease the potential difference from $6.5\ \text{kV}$ to $240\ \text{V}$.

Calculate the number of turns in the secondary coil of the transformer.

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____ (2 marks)

The table below shows the potential difference and the frequency of the electricity supply for a variety of countries.

Region	Country	Electricity supply	
		Potential difference (V)	Frequency (Hz)
Asia Pacific	Australia	240	50
	China	220	50
	Malaysia	230	50
	Indonesia	220	50
North America	Canada	110	60
	United States	120	60
Europe	France	220	50
	Germany	220	50

(b) A Canadian person is travelling to Europe.

Explain which portable transformer (step-up or step-down) is needed in order to use personal electronic equipment taken from Canada to Europe.

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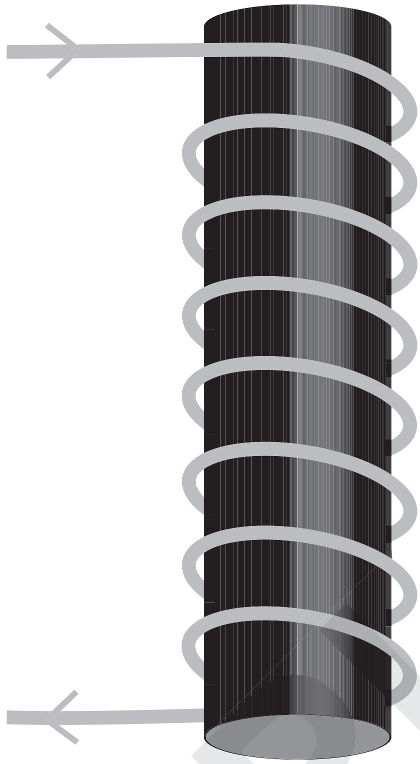
____ (3 marks)

11. (a) The diagram below shows a solenoid with 8 turns and a solid iron core with a cross-sectional area of 7.1×10^{-4} m^2. When the current in the solenoid is constant, there is a magnetic field in the iron core, but no induced eddy current. When the current in the solenoid is changing, there is an induced eddy current in the iron core.



(i) (1) *On the diagram above*, draw and label an arrow, showing the direction of the magnetic field in the iron core when there is a constant current in the coil in the direction shown on the diagram. (1 mark)

(2) Using proportionality, predict the effect on the magnitude of the magnetic field in the iron core when the current in the coil is halved.

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____ (2 marks)

(ii) When the current source is turned off, the current in the coil reduces to zero in a time of 0.0050 s, causing the magnetic field strength to decrease from 4.56×10^{-3} T to zero.

(1) Calculate the magnitude of the induced *emf*.

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____ (3 marks)

(2) *On the diagram on page 15*, draw and label the direction of an eddy current in the iron core as the current in the coil is decreased to zero. Justify your answer using Lenz's Law.

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Credit will be given for answers to part (b) that are coherent and contain only relevant information.

(2 marks)

(b) Changing magnetic fields have a number of applications.

Describe an application that uses a changing magnetic field and explain how the changing magnetic field is used in this application.

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(7 marks)

You may write on this page if you need more space to finish your answers to Question Booklet 1. Make sure to label each answer carefully (e.g. 9(a) continued).

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