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PHYSICS

2019

Trial Examination

(2 hours 30 minutes)

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	20	20	20
B	20	20	110
			Total 130

(Note: Use the formula/data sheets supplied by VCAA)

SECTION A –20 Multiple-choice questions (20 marks)

Instructions for Section A Answer **all** questions in this section. Choose the response that is **correct** or that **best answers** the question. A correct answer scores 1; an incorrect answer scores 0. Marks will **not** be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question. Unless otherwise indicated, the diagrams are **not** drawn to scale. Take the value of g to be 9.80 N kg $^{-1}$.

Question 1
Consider the three fields: gravitational, electric and magnetic.
Which one of the following statements is **NOT** correct?

A. All three fields can be approximately uniform in a relatively small region.

B. All three fields are vector quantities.

C. All three fields follow the inverse square law.

D. All three fields can be static.

Question 2
Consider two point charges at certain distance apart.
Which one of the following statements is **NOT** correct?

A. The force between the two charges can be attractive or repulsive.

B. The force between the two charges remains the same if the distance and one of the charges are doubled.

C. The force experienced by a third point charge varies with its position from the two charges.

D. A third point charge will either move towards one of the two charges or away from both charges.

Question 3
A neutral (no charge) particle moves in space near Earth but outside the Earth's atmosphere.
Which one of the following statements **CANNOT** be correct?

A. The particle is in freefall if it moves in a straight line towards the centre of Earth.

B. The particle is in freefall if it moves in a curved path towards Earth.

C. The particle is in freefall if it moves in a curved path away from Earth.

D. The particle is in freefall if it moves in a straight line past Earth.

Question 4
Which one of the following statements is correct when a positively charged particle moves away from another positively charged particle?

A. Electric potential energy increases.

B. Electric potential energy increases to infinity.

C. Electric potential energy remains constant.

D. Electric potential energy decreases to zero.

Question 5
Point P is 0.25 m east of a bar magnet. The south pole of the bar magnet is facing eastward, and at point P the magnitude of its magnetic field equals the magnitude of Earth's magnetic field of *B* tesla.
The net magnetic field at point P is approximately
(Select one of the following alternatives)

A. $2B$ tesla NE

B. $1.4B$ tesla SE

C. $2B$ tesla SW

D. $1.4B$ tesla NW

Question 6
A carriage moves along a circular track of a rollercoaster in a vertical plane. The carriage is upright at the highest point of the track. Which one of the following statements describes an **impossible** situation?

A. All riders in the carriage feel weightless.

B. All riders in the carriage experience an upward reaction force.

C. All riders in the carriage experience a downward reaction force.

D. All riders in the carriage have zero acceleration.

Question 7
Which one of the following statements about geostationary satellites is **NOT** correct?

A. All geostationary satellites have the same speed.

B. All geostationary satellites have the same period.

C. All geostationary satellites have the same kinetic energy.

D. All geostationary satellites have the same acceleration towards the centre of Earth.

Question 8
A particle with mass m and charge q is placed between two parallel metal plates. The two plates have a potential difference V and are separated by a distance d. The force of gravity on the particle is negligible.
Which one of the following statements is **NOT** correct?

A. The acceleration of the particle is proportional to qV.

B. The acceleration of the particle is proportional to $\frac{q}{m}$.

C. The acceleration of the particle is proportional to md.

D. The acceleration of the particle is proportional to $\frac{V}{d}$.

Question 9
A student measures the length of a rectangle as 2.3 cm with a ruler (graduated in cm) and the width as 5.5 mm with another ruler (graduated in mm). Taking precision into consideration the perimeter of the rectangle is (Select one of the following alternatives)

A. 5.6 cm

B. 57 mm

C. 5.70 cm

D. 58 mm

Question 10
Imagine a spacecraft travelling at constant velocity $0.8c$ past Earth and then Mars. An observer in the spacecraft measures the time of travel between Earth and Mars to be T, and the distance between Earth and Mars to be D.

Which one of the following statements about T and D is correct?

A. T is the proper time interval and D is the contracted distance

B. T is the proper time interval and D is the proper distance

C. T is the dilated time interval and D is the contracted distance

D. T is the dilated time interval and D is the proper distance

Question 11
A rectangular loop moves at constant velocity completely inside a uniform magnetic field.
The induced current in the loop
(Select one of the following alternatives)

A. is in the clockwise direction

B. is in the anticlockwise direction

C. is zero

D. cannot be determined without more information

Question 12
Polarisation of light demonstrates
(Select one of the following alternatives)

A. the particle nature of light

B. the wave nature of light

C. the wave-particle dual nature of light

D. that matter has wave nature

Question 13
The speed of sound is 344.5 m s^{-1}. A compression of a sound wave of constant frequency passes point P. Another compression of the same sound wave passes point P one second later.
The frequency (Hz) of the sound wave is
(Select one of the following alternatives)

A. 108.7

B. 60.5

C. 55.3

D. 50.0

Question 14
A 1-kg particle is projected horizontally and a 2-kg particle is projected at $60°$ above the horizontal.
Both particles are projected at the same speed at the same time from the same point above the ground.
Both particles travel in the same vertical plane. Ignore air resistance in this question.
Which one of the following statements is correct?

A. Both particles hit the ground at the same speed.

B. Both particles hit the ground with the same kinetic energy.

C. Both particles hit the ground at the same angle.

D. Both particles hit the ground at the same time.

Question 15
A ray of light of a particular frequency enters a transparent substance of absolute refractive index n_s from air of absolute refractive index $n_a = 1.000$.
Select one of the following alternatives, the speed of the light in the transparent substance is proportional to

A. n_s

B. n_a

C. the angle of the refracted ray with the normal

D. the wavelength of the light

Question 16
Which one of the following statements best explains/describes the resonance of sound?

A. Resonance is the interference of two travelling sound waves

B. Resonance occurs whenever a sound wave enters a closed pipe of air

C. Resonance occurs if a standing wave is formed by the superposition of a travelling sound wave and its reflection

D. Resonance cannot occur when a sound wave enters an open pipe of air

Question 17
The input of a transformer is connected to a power source.
While the input voltage decreases uniformly from 12 V to -12 V, which one of the following statements is the best description of the output voltage of the transformer?

A. The output increases uniformly from 0 V to 24 V

B. The output decreases uniformly from 24 V to 0 V

C. The output is approximately constant

D. The output is constant at -12 V and then constant at 12 V, or vice versa

Question 18
A student placed a sample on an electronic scale and took five readings in grams.
The readings were 2.51, 2.62, 2.45, 2.58 and 2.41.
Which one of the following results in grams should be recorded as the mass of the sample?

A. 2.514 ± 0.106

B. 2.514 ± 0.104

C. 2.51 ± 0.11

D. 2.5 ± 0.1

Question 19
A photocurrent of $0.80\ \mu$A is measured in a photoelectric effect experiment using light of a fixed frequency.
Which one of the following values for the number of photons absorbed in one second causing the emission of photoelectrons is the most appropriate?

A. 1.0×10^{6}

B. 2.0×10^{9}

C. 5.0×10^{12}

D. 8.0×10^{15}

Question 20
A particle of mass m moves at a speed of $0.9c$, where c is the speed of light.
Which one of the following values best represent the kinetic energy of the electron?

A. $0.405mc^{2}$

B. $1.294mc^{2}$

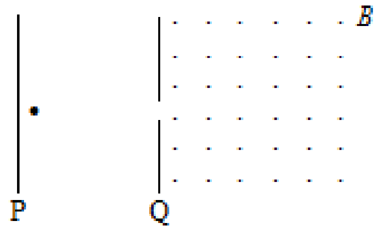
C. $2.162mc^{2}$

D. $3.162mc^{2}$

SECTION B

Instructions for Section B
Answer **all** questions in this section.
Where an answer box is provided, write your final answer in the box.
If an answer box has a unit printed in it, give your answer in that unit.
In questions where more than one mark is available, appropriate working **must** be shown.
Unless otherwise indicated, the diagrams are **not** drawn to scale.
Take the value of g to be 9.80 N kg^{-1}.

Question 1
Two parallel metal plates P and Q are 5.0 cm apart. The electric potential difference between P and Q is 250 V. An electron starts from rest and accelerates from P to Q. Plate Q has a hole in the middle to allow the electron to pass through into a uniform magnetic field B of 0.010 T perpendicular to the motion of the electron and directed out of the page (refer to the following diagram).



a. Calculate the force of gravity and the electric force on the electron between the two parallel plates P and Q. Compare the magnitudes of the two forces and comment on the path of the electron.

3 marks

N	N

b. Calculate the kinetic energy of the electron when it passes through the hole in Plate Q. 2 marks

J

c. Calculate the magnetic force on the electron once it enters the magnetic field B. 2 marks

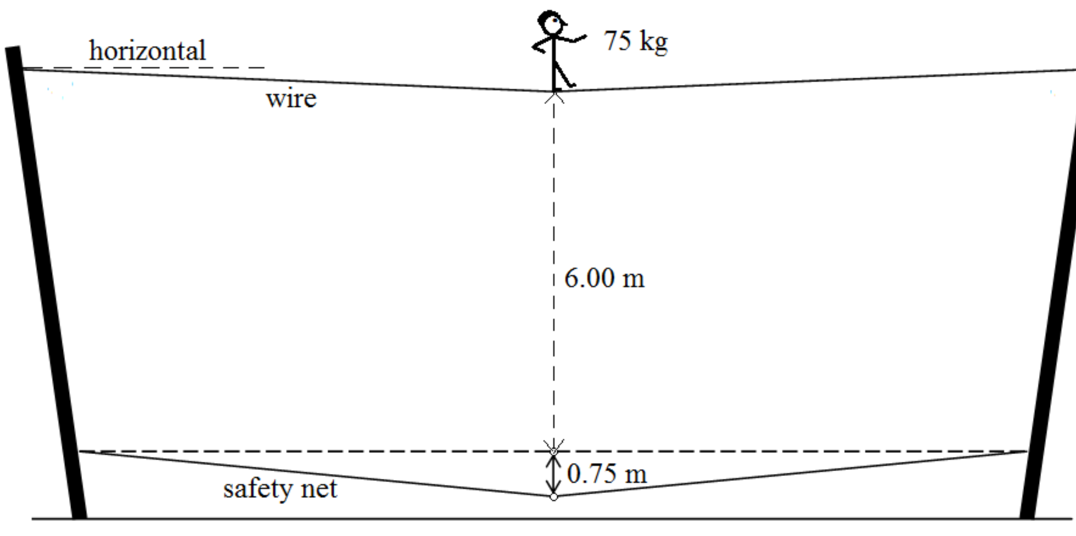
N

d. Describe the motion of the electron in the magnetic field B in terms of its path, speed and acceleration.

3 marks

m s^{-1}	m s^{-2}

Question 2
While in the middle of the wire, a 75 kg circus clown causes it to make a $5°$ angle to the horizontal at both ends.



a. Calculate the tension in the wire. 2 marks

N

b. The clown falls 6.00 m to the safety net, depressing the net by 0.75 m. Assume the net is elastic (i.e. it follows Hooke's law) calculate the amount of elastic potential energy in the net when it is depressed by 0.75 m.

2 marks

J

c. Calculate the force required to depress the net by 1 m. 2 marks

N

d. Calculate the maximum force exerted by the net on the clown. 2 marks

N

e. Describe the subsequent motion of the clown if the net is truly elastic. 1 mark

Question 3

A spacecraft travels past the moon of planet Earth towards Earth at a speed of v m s^{-1}.

The half lives of a sample of a particular radioisotope carried inside the spacecraft are determined by an astronaut inside the spacecraft and by a scientist on Earth. They are 4.0 s by the astronaut and 5.0 s by the scientist.

a. Calculate the value of the ratio $\frac{v}{c}$ where c m s^{-1} is the speed of light. 2 marks

b. The distance from planet Earth to its moon is 3.80×10^{8} m measured by the scientist. What is the distance from the moon to planet Earth measured by the astronaut?

2 marks

m

c. Find the time measured by the astronaut to travel from the moon to planet Earth. 2 marks

s

Question 4
A tennis ball moves in a parabolic path under gravity. It has a velocity of 25.0 m s^{-1} at $60°$ angle with the vertical just before it hits the ground.

a. Determine the minimum speed of the tennis ball while it is in flight. 2 marks

m s^{-1}

b. Determine the maximum height of the tennis ball above the ground. 2 marks

m

Question 5
An electron travels at 99% of the speed of light.

a. Find the mass of the electron travelling at 99% of the speed of light. 1 mark

kg

b. Find the sum of rest energy and kinetic energy of the electron travelling at 99% of the speed of light.

2 marks

J

Question 6

An Earth satellite is placed in a circular orbit where $g = 0.22\ \text{N kg}^{-1}$.

a. Calculate the altitude of the satellite. 2 marks

m

b. Calculate the period of the satellite. 2 marks

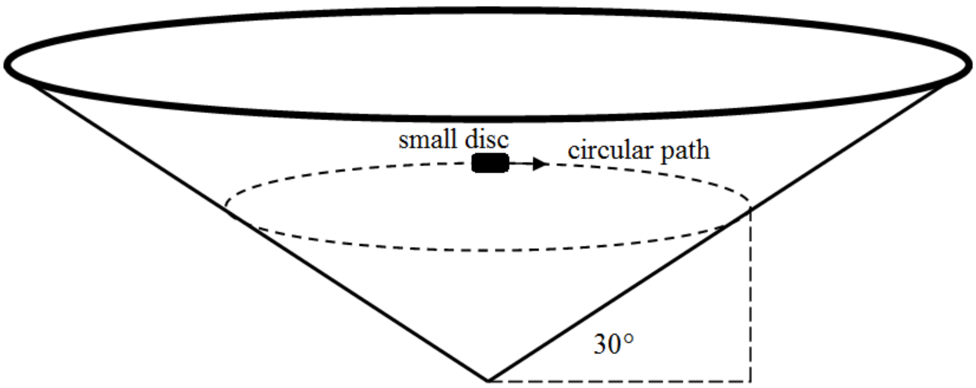
s

c. Estimate the increase in gravitational potential energy for each kilogram of the satellite when its altitude is increased by 1 km.

2 marks

J

Question 7
A small disc slides in a horizontal circular path on the inside wall of a conical structure.
The inside wall is icy and there is no friction between the disc and the wall.
The circular path has a radius of 5.00 metres.



a. Calculate the speed of the disc. 2 marks

$m\ s^{-1}$

b. Calculate the change in the height of the disc above the ground if its speed is changed to $6.00\ m\ s^{-1}$.
2 marks

m

Question 8
A stretched wire is 0.48 m long.
One of the resonant frequencies of the stretched wire is 150 Hz. The next higher resonant frequency is 200 Hz.

a. Calculate the wavelength of the 150 Hz frequency. 2 marks

m

b. Determine the wave speed of a 175 Hz transverse wave travelling in the stretched wire. 2 marks

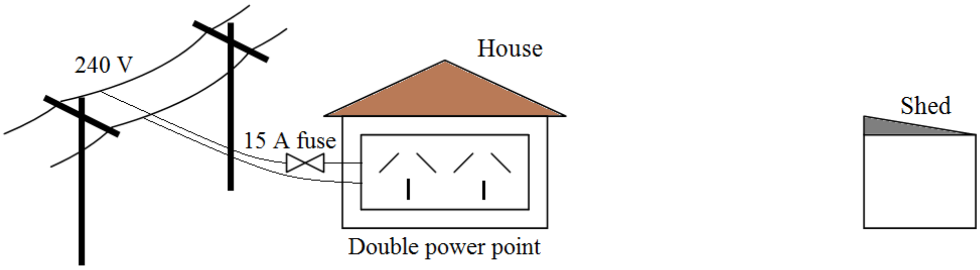
$m\ s^{-1}$

c. The 150 Hz vibration of the stretched wire produces a sound wave in the air.
Estimate the wavelength of the sound wave produced. 1 mark

m

Question 9
If you are in a car travelling at high speed towards the sounding siren of a stationary police car, the siren sounds at higher pitch than when you are at rest next to the police car.
Explain this effect in terms of sound speed and frequency 3 marks

Question 10
The power point inside a house has a 15 amp fuse.



a. Discuss with calculations the effect if any on the 15 amp fuse when two 2.20 kW kettles are connected to the double power point (a power point with two outlets).

3 marks

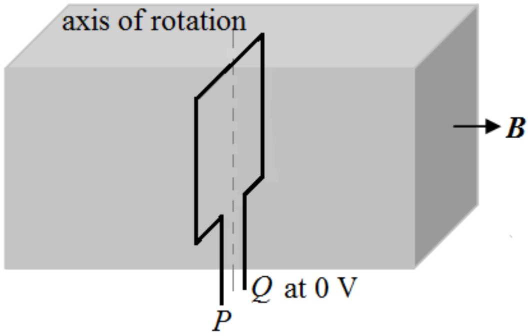
A power tool has a specified voltage range of 220 - 240 V and is rated maximum 3.00 kW at 240 V.
Assume that the resistance of the power tool is constant.
The total resistance per metre of an extension cord is $0.025\,\Omega$.
The resident wants to operate the power tool in the shed by the extension cord connected to an outlet of the double power point in the house.

b. Determine whether the power tool is operational if the shed is 50 m from the house. Show calculations.

3 marks

Question 11

A rectangular coil consists of **50 turns** of insulated copper wire.
The coil has a height of 10.0 cm and a width of 6.0 cm.
It is placed in a uniform magnetic field ***B*** of 4.0×10^{-5} T.
Terminal Q is at 0 V.



a. Calculate the magnetic flux through the coil. 1 mark

wb

b. Determine the torque on the coil about the axis of rotation if a 0.50 A current flows from P to Q and magnetic field ***B*** is perpendicular to the enclosed area of the coil as shown in the diagram.

1 mark

Nm

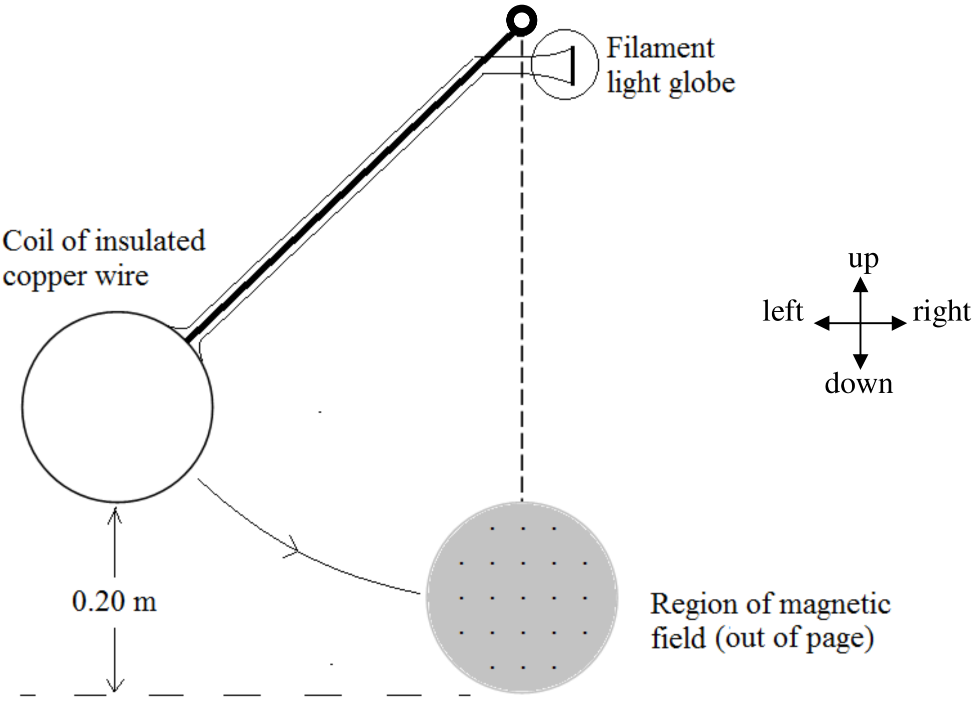
Now the coil is in uniform rotation about the axis at a frequency of 5.0 Hz.

c. Calculate the average signed (+ or −) potential relative to terminal Q induced at terminal P after 0.050 s from the position shown in the diagram.

4 marks

V

Question 12
The pendulum bob is a coil of wire of mass 0.50 kg. The diagram shows its initial position.
The coil has enough turns to light up the filament globe when it swings pass the region of magnetic field.
Ignore air resistance and friction in this question. The mass of the pendulum arm is insignificant.



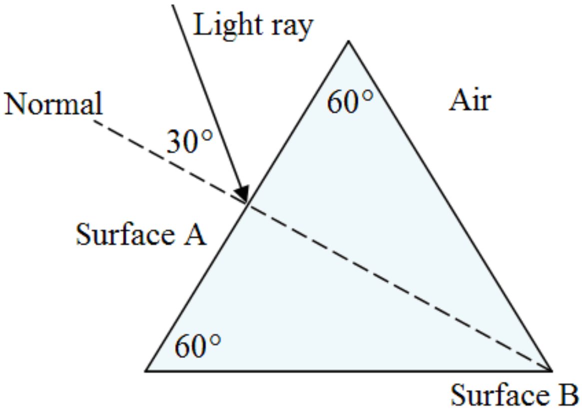
a. Describe and explain the subsequent motion of the pendulum bob qualitatively.
In your discussion include forces when the pendulum bob enters or leaves the region of magnetic field, and the height reached when it swings to the other side.

3 marks

b. Determine the total amount of electrical energy dissipated in the light globe. 2 marks

	J

Question 13
A light ray has blue and red components.
The ray is directed to a triangular prism at $30°$ angle with the normal to Surface A of the prism.
The absolute refractive index of the prism is 1.514 for the red component, and 1.528 for the blue component.
Assume that the absolute refractive index of air is 1.00.



a. Calculate the angles of refraction for the red and blue components. 2 marks

Red	Blue

b. On the diagram above accurately sketch and label the red (r) and blue (b) components to Surface B.
1 mark

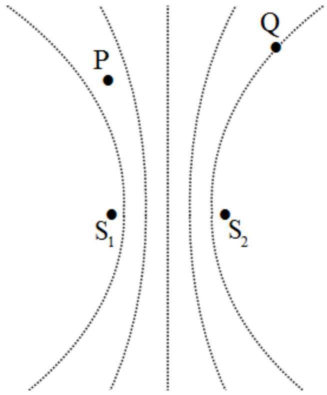
c. Calculate the critical angles for total internal reflection for both components. 2 marks

Red	Blue

d. On the same diagram above extend (sketch accurately and label) the two components beyond Surface B.
2 marks

Question 14

Circular water waves of wavelength $\lambda = 2.0\,\text{cm}$ are generated by two nails dipping in and out of calm water at the same frequency but out of phase by half of a period. An interference pattern is formed.
Only nodal lines (dotted) between the two nails are shown in the diagram below.
P and Q are two locations at the water surface. S_1 and S_2 are the locations of Nail 1 and Nail 2 respectively.



Not drawn to scale

a. How far apart are the two nails? 1 mark

m

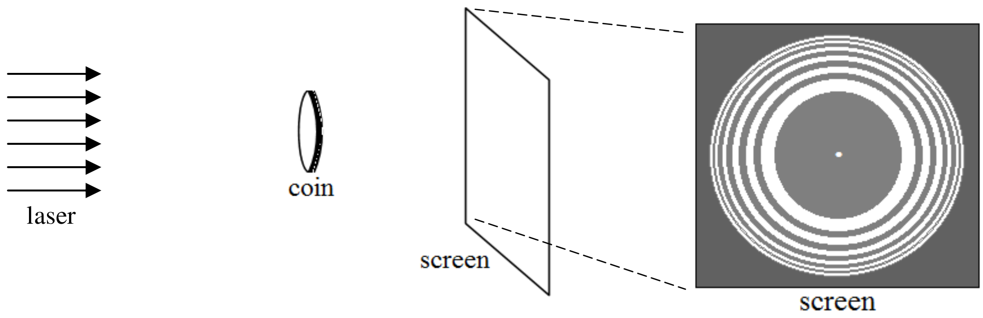
b. Explain the formation of nodal lines in the pattern. 1 mark

c. Calculate the difference in distances QS_1 and QS_2. 2 marks

m

d. A cork floats at location P just before the generation of circular waves.
Describe the motion of the cork as time progresses. 2 marks

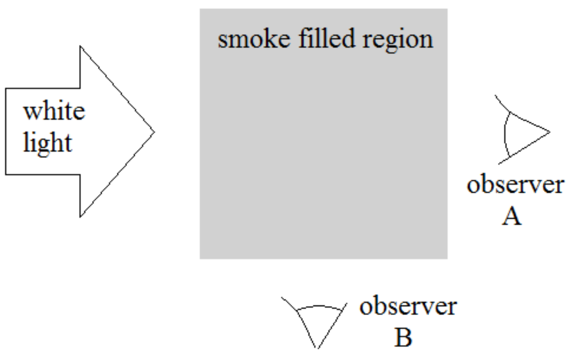
Question 15
In the following experiment the shadow cast by a coin using a laser as a source of light appears on the screen. There is a bright spot at the centre of the shadow, and there are also bright and dark fringes beyond the shadow.



Explain clearly the appearance of the bright spot at the centre of the shadow, and the formation of the bright and dark fringes beyond the shadow.

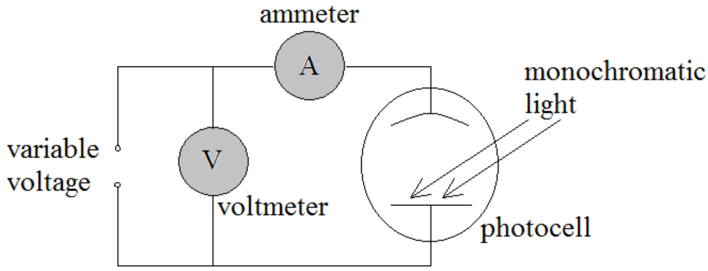
3 marks

Question 16
Given data: The size of smoke particles is in the range 0.1×10^{-6} to 1.0×10^{-6} m.
Wavelength of visible light has a range 0.4×10^{-6} to 0.7×10^{-6} m.



Describe and explain the observation of each observer in terms of light colours. 3 marks

Question 17
The following diagram shows a setup to investigate the photoelectric effect for certain light intensities and wavelengths.

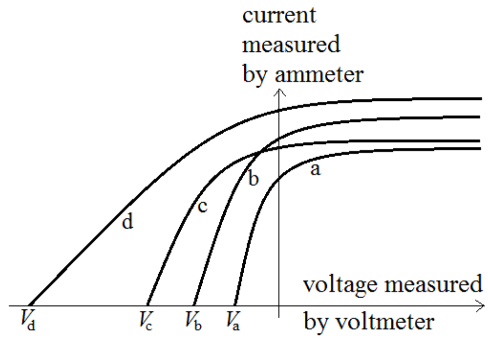


a. The two important properties of a light wave are its intensity and its frequency (or wavelength). What does the wave model of light predict about the number of emitted electrons and the kinetic energy of the electrons when the intensity and frequency of the light wave are varied?

2 marks

Four monochromatic lights labeled as a, b, c and d of different wavelengths and intensities are directed at the same photocell. Voltage is varied and current is measured. The results are recorded and graphed below.

Light x	Wavelength λ_x (nm)	Voltage $\lvert V_x \rvert$ (V)
a	700	0.500
b	650	0.637
c	600	0.796
d	410	1.755



b. Calculate the photon energy of the monochromatic light labeled as d, and the maximum speed of the emitted electrons.

3 marks

eV	m s^{-1}

c. Are the results in the table consistent? Explain with calculations. 2 marks

d. There is a wavelength below which emission of photoelectrons occurs. Determine that wavelength.

2 marks

m

Question 18

Heisenberg's uncertainty principle is stated mathematically as $\Delta p_x \Delta x \geq \frac{h}{4\pi}$.

Explain how diffraction from a single slit experiment can be used to illustrate the principle. 2 marks

Question 19

Interpret the interference pattern (bright and dark fringes) produced when very dim light (one photon at a time) is used in a double slit experiment.

2 marks

Question 20

A load is suspended by a supported spring when two students, A and B, investigate the relationship between the mass M of a load and the period T of oscillation of the load.
Four other factors involved in this investigation are air resistance r, mass of the spring m, elastic constant k of the spring and gravity g.
The spring extends further by 0.015 m for each additional 0.05 kg.
The spring can be extended up to 0.30 m before losing its elasticity.

a. Identify the controlled, dependent and independent variables in this investigation. 2 marks

b. Suggest a way to minimise the effect of (i) air resistance and (ii) the mass of the spring on the investigation.
2 marks

The results of the investigation by the two capable students are tabulated together as shown below.

Student	Mass of load (kg)	Time for 20 oscillations (s)	Period (s)
A	0.100	7.7 ± 0.4	0.385
A	0.150	10.1 ± 0.4	0.505
A	0.200	11.6 ± 0.4	0.580
B	0.250	13.0 ± 0.5	0.650
B	0.300	14.5 ± 0.5	0.725
B	0.350	15.4 ± 0.5	0.770

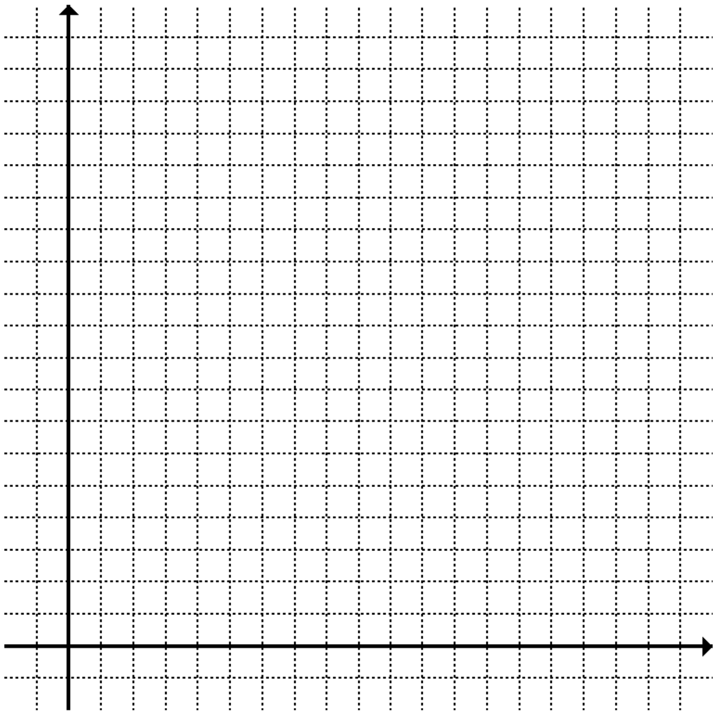
Note: The time for 20 oscillations is measured with a stopwatch and it is the average value of 5 repeated measurements for the same load.

c. The calculated values in the last column of the table above are not quite correct with respect to accuracy. Enter the correct values including uncertainties for the periods in the following table. 2 marks

Student	Mass of load (kg)	Time for 20 oscillations (s)	Period (s)
A	0.100	7.7 ± 0.4	
A	0.150	10.1 ± 0.4	
A	0.200	11.6 ± 0.4	
B	0.250	13.0 ± 0.5	
B	0.300	14.5 ± 0.5	
B	0.350	15.4 ± 0.5	

d. Analyse the results and determine the relationship between M (mass of load) and T (period of oscillation). The use of the grid below is optional.

3 marks



e. Suggest a way to improve the investigation so that the relationship between M and T can be ascertain for the spring. This question is not about accuracy and human errors.

2 marks

End of examination

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2019 Physics Trial Exam Solutions

SECTION A

1	2	3	4	5	6	7	8	9	10
C	B	D	D	D	D	C	C	D	C

11	12	13	14	15	16	17	18	19	20
C	B	D	A	D	C	C	D	C	B

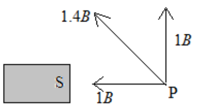
Q1 Electric field between two oppositely charged plates is constant.

Q2 Double the charge on one will double the force, double the distance the force will become a quarter of the original value. Overall the force will be halved.

Q3 Unless the particle moves towards the Earth centre, a force is required to overcome the gravity of Earth. .: the particle is not in freefall.

Q4 Electric potential energy is highest when like charges are closest because of the repulsive force between them.

Q5



Q6 All riders have acceleration pointing towards the centre of the circle.

Q7 Geostationary satellites all have the same speed but they can be different in mass, .: different kinetic energy.

Q8 $E=\frac{F}{q}=\frac{ma}{q}=\frac{V}{d}$, .: $a=\frac{qV}{md}$, a is inversely proportional to md, not proportional.

Q9 Before adding/subtracting all measurements need to be corrected to the same number of decimal places as the least precise measurement.

$2.3\text{ cm}+5.5\text{ mm}+2.3\text{ cm}+5.5\text{ mm}$

$=2.3\text{ cm}+0.6\text{ cm}+2.3\text{ cm}+0.6\text{ cm}=5.8\text{ cm}=58\text{ mm}$

Q10

Q11 No change in magnetic flux

Q12

Q13 Let n be the number of periods between the first compression and another compression, .: n must be a whole number. $T=\frac{1\text{ second}}{n}=\frac{1}{f}$, .: $f=n$, 50.0 is closest to a whole number.

Q14 Energy consideration: $\frac{1}{2}mu^2+mgh=\frac{1}{2}mv^2$

.: $v^2=u^2+2gh$

Q15 $n_s v_s=n_a v_a$, $v_s=\frac{1.000v_a}{n_s}=\frac{1.000f\lambda_a}{n_s}=1.000f\lambda_s$

.: $v_s\propto\lambda_a$ or λ_s

Q16 A travelling sound wave and its reflection have the **same frequency**. The superposition of the two waves produces a standing wave.

Q17 A uniformly decreasing input voltage produces a constant rate of change in magnetic flux through the secondary coil. Hence a constant voltage is induced at the transformer output.

Q18 Uncertainties have single digit.

Q19 $\frac{0.80\times10^{-6}}{1.6\times10^{-19}}=5.0\times10^{12}$

Q20 $E_{\text{k}}=(\gamma-1)mc^2\approx1.294mc^2$

SECTION B

Q1a $E=\frac{V}{d}=\frac{250}{0.050}=5000\ \text{NC}^{-1}$

Electric force $F=qE=1.6\times10^{-19}\times5000=8.0\times10^{-16}\,\text{N}$

Force of gravity $F=mg=9.1\times10^{-31}\times9.8\approx8.9\times10^{-30}\,\text{N}$

Force of gravity is very much less than the electric force, .: it has no significant effect on the straight line path of the electron.

Q1b $E_{\text{k}}=$ work done on the electron by the electric force $=8.0\times10^{-16}\times0.050=4.0\times10^{-17}\,\text{J}$

Q1c $F=qvB=q\sqrt{\frac{2E_{\text{k}}}{m}}B$

$=1.6\times10^{-19}\times\sqrt{\frac{2\times4.0\times10^{-17}}{9.1\times10^{-31}}}\times0.010$

$\approx1.5\times10^{-14}$ N perpendicular to the motion of the electron

Q1d The constant force perpendicular to the motion causes the electron to move in a semi-circular path at the constant speed of $\sqrt{\frac{2\times4.0\times10^{-17}}{9.1\times10^{-31}}}\approx9.4\times10^{6}\ \text{m s}^{-1}$.

Acceleration $=\frac{F}{m}=\frac{1.5\times10^{-14}}{9.1\times10^{-31}}\approx1.6\times10^{16}\ \text{m s}^{-2}$.

Radius $=\frac{v^2}{a}\approx\frac{8.8\times10^{13}}{1.6\times10^{16}}\approx0.005\text{ m}$

The path curves upward and the electron hits Plate Q at the end of the semi-circular path.

Q2a $2T\sin 5° = 75\times 9.80$, $T \approx 4.2\times 10^3$ N

Q2b Elastic potential energy = gravitational potential energy $= 75\times 9.80\times(6.00+0.75) \approx 5.0\times 10^3$ J

Q2c $\frac{1}{2}k\times 0.75^2 = 75\times 9.80\times(6.00+0.75)$,

$k \approx 1.8\times 10^4$ N m^{-1} (17640)

Force required to depress the net by 1 m $\approx 1.8\times 10^4$ N

Q2d Maximum force $= kx \approx 17640\times 0.75 \approx 1.3\times 10^4$ N

Q2e If air resistance is insignificant, the clown will rebound to a height 6.00 m above the hozizontal net and the motion repeats.

Q3a $5.0 = 4.0\times\frac{1}{\sqrt{1-\left(\frac{v}{c}\right)^2}}$, $\sqrt{1-\left(\frac{v}{c}\right)^2} = 0.80$, $\frac{v}{c} = 0.6$

Q3b Contracted distance $= 3.80\times 10^8\times 0.80 \approx 3.04\times 10^8$ m

Q3c Time measured by astronaut $= \frac{3.04\times 10^8}{0.6c} \approx 1.7$ s

Q4a Minimum speed

$=$ constant horizontal component of velocity

$= 25.0\sin 60° \approx 21.7$ m s^{-1}

Q4b Vertical component: $u = 0$, $v = -25.0\cos 60° = -12.5$

$a = -9.8$, .: $s \approx -7.97$, maximum height ≈ 7.97 m

Q5a Mass of electron at $0.99c$ $= \frac{9.1\times 10^{-31}}{\sqrt{1-0.99^2}} \approx 6.5\times 10^{-30}$ kg

Q5b Rest energy + kinetic energy $= E_{\text{total}} = \gamma mc^2 \approx 2.0\times 10^{-13}$ J

Q6a $r = \sqrt{\frac{GM}{g}} = \sqrt{\frac{(6.67\times 10^{-11})(5.98\times 10^{24})}{0.22}} \approx 4.26\times 10^7$ m

Altitude $\approx 4.26\times 10^7 - 6.37\times 10^6 \approx 3.6\times 10^7$ m

Q6b $T = 2\pi\sqrt{\frac{r}{g}} = 2\pi\sqrt{\frac{4.26\times 10^7}{0.22}} \approx 8.74\times 10^4$ s

Q6c Increase in gravitational potential energy

$\approx mgh = 1\times 0.22\times 1000 = 2.2\times 10^2$ J

Q7a $\frac{mv^2}{5.00} = 9.80m\tan 30°$, $v \approx 5.32$ m s^{-1}

Q7b $\frac{m6.00^2}{r} = 9.80m\tan 30°$, $r \approx 6.36$

$\frac{\Delta h}{6.36-5.00} \approx \tan 30°$, $\Delta h \approx 0.79$ m

Q8a 150 Hz is the third harmonic, $\frac{3\lambda}{2} = 0.48$, $\lambda = 0.32$ m

Q8b Same speed for wave of any frequency travelling in the same wire, $v = f\lambda = 150\times 0.32 = 48$ m s^{-1}

Q8c 345 m s^{-1}

Q9 The speed of sound increases relative to you inside a car approaching at high speed the sounding siren of the stationary police car. Since $f = \frac{v}{\lambda}$ and the sound wavelength remains constant, .: $f \propto v$, higher sound speed, higher frequency, higher pitch.

Q10a $240\times I = 2\times 2200$, $I \approx 18.3$ A, this amount of current is over the current allowed for the fuse rated 15 A. The fuse will be blown to prevent overheating of the wiring in the house.

Q10b Total resistance of extension cord $= 0.025\times 50 = 1.25$ Ω

Resistance of the power tool $= \frac{240^2}{3000} = 19.2$ Ω

Current through the power tool $= \frac{240}{19.2+1.25} \approx 11.74$ A

Voltage across power tool $\approx 11.74\times 19.2 \approx 225$ V which is within 220 - 240 V. The power tool is operational.

Q11a $\phi = 0.10\times 0.06\times 4.0\times 10^{-5} = 2.4\times 10^{-7}$ wb

Q11b $\tau = 0$

Q11c $T = \frac{1}{5.0} = 0.20$ s, 0.050 s is the time for a quarter turn.

Magnetic flux changes from maximum to zero.

The induced current flows from Q to P through the coil.

.: terminal P is at a higher potential relative to Q.

$|\xi| = 50\times\frac{2.4\times 10^{-7}}{0.050} = 2.4\times 10^{-4}$ V

Average potential at P is $+2.4\times 10^{-4}$ V.

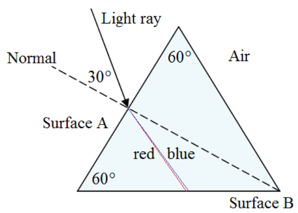
Q12a As the right side of the coil enters the magnetic field, a clockwise current is induced in it and the magnetic field exerts a force opposite to its motion. This force retards the motion of the coil. As the left side of the coil leaves the magnetic field, an anticlockwise current is induced in it and the magnetic field again exerts a force opposite to its motion. Every time the coil swings past the magnetic field it is retarded by the magnetic force and its height drops at the end of a swing. This gradually reduces the amplitude of the swinging coil.

Q12b Gravitational potential energy changes to electrical energy $= mgh = 0.50\times 9.80\times 0.20 = 0.98$ J

Q13a Red: $\sin\theta = \frac{0.5}{1.514}$, $\theta \approx 19.3°$

Blue: $\sin\theta = \frac{0.5}{1.528}$, $\theta \approx 19.1°$

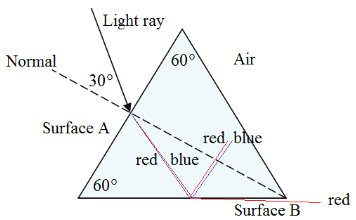
Q13b



Q13c Red: $\theta_c = \sin^{-1}\left(\frac{1}{1.514}\right) \approx 41.34°$

Blue: $\theta_c = \sin^{-1}\left(\frac{1}{1.528}\right) \approx 40.88°$

Q13d For the blue component the angle of incidence at surface B is $180-120-19.1 = 40.9°$. It is greater than the critical angle. Total internal reflection will occur for the blue component.
For the red component the angle of incidence at surface B is $180-120-19.3 = 40.7°$. It is less than the critical angle.
Some internal reflection as well as refraction into air will occur for the red component.



Q14a Approximately $5\times\frac{\lambda}{2} \approx 5.0\,\text{cm}$ or $0.050\,\text{m}$

Q14b When the waves from the two sources meet, destructive interference occurs when the waves are out of phase by half of a period. At places (nodal lines) where this occurs the water surface is fairly calm.

Q14c $QS_1 - QS_2 = 2\lambda = 4.0\,\text{cm}$ or $0.040\,\text{m}$

Q14d Location P is on an anti-nodal line (region of constructive interference). Water surface at P oscillates at maximum amplitude, the sum of the amplitudes of the waves from the two sources. The cork moves up and down (no horizontal motion) at P as time progresses and at the same frequency as the waves.

Q15 Light passing the coin edge diffracts. Some light will diffract behind the coin. At the central axis diffracted light interfere constructively and if the screen is at the right distance from the coin, a bright spot appears. Some light will diffract away from the coin. Constructive and destructive interferences occur forming the bright and dark fringes around the shadow.

Q16 Wavelength λ of visible light is about the size w of smoke particles, .: diffraction occurs for visible light. Since the extent of diffraction $\propto \frac{\lambda}{w}$, .: light of longer wavelength (red end of the visible spectrum) diffracts more than light of shorter wavelength (blue end). Observer A will see more light from the red end of the spectrum. Light from the blue end will be scattered in all directions by the smoke particles and some to Observer B.

Q17a Wave model: Varying frequency of light has no effects on the number and kinetic energy of emitted electrons.
Light energy is related to the amplitude of the light wave.
Brighter light (larger amplitude) will pass on more energy to the electrons and they will be emitted with higher kinetic energy.
The number of emitted electrons remains constant.

Q17b $E = \frac{hc}{\lambda} = \frac{(4.14\times10^{-15})(3.0\times10^{8})}{410\times10^{-9}} \approx 3.0\,\text{eV}$

Max $E_k = 3.03 - 1.755 \approx 1.27$ eV,

$\frac{1}{2}\times9.1\times10^{-31}v^2 \approx 1.27\times1.6\times10^{-19}$, $v \approx 6.7\times10^{5}\ \text{m s}^{-1}$

Q17c The results are consistent. Use any two pairs of data, $hc \approx 1.24\times10^{-6}$ eVm

Q17d Max $E_k = \frac{hc}{\lambda} - \phi$,

$\phi = \frac{hc}{\lambda} - \max E_k \approx \frac{1.24\times10^{-6}}{700\times10^{-9}} - 0.500 \approx 1.27$ eV

$\frac{hc}{\lambda} = \phi$, $\frac{1.24\times10^{-6}}{\lambda} \approx 1.27$, $\lambda \approx 9.8\times10^{-7}$ m

Q18 When a photon passes through a single slit, there is uncertainty Δx (width of the slit) in its position at the slit.
According to Heisenberg's uncertainty principle $\Delta p_x \Delta x \geq \frac{h}{4\pi}$, the uncertainty in its momentum Δp_x (direction spread) increases as uncertainty in its position Δx decreases. This explains the widening of the diffraction pattern when the width of the slit decreases.

Q19 An interference pattern appears over time when very dim light (as dim as one photon at a time) is used in a double slit experiment. To explain this, one can consider a single photon as a wave itself. The single photon, being a particle itself, behaves like a wave as well to produce the pattern. This experiment demonstrates the wave-particle duality of light.

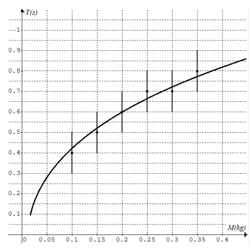
Q20a Dependent: period T Independent: mass of load M
Controlled: air resistance r, mass of spring m, elastic constant k, and gravity g

Q20b Reduce air resistance by using a smooth dense (large in mass but small in volume) load. Choose a spring with insignificant mass in comparison with the mass of the load.

Q20c

Period (s)
0.4 ±0.1
0.5 ±0.1
0.6 ±0.1
0.7 ±0.1
0.7 ±0.1
0.8 ±0.1

Q20d



The shape of the curve suggests that $T \propto M^n$ where $0 < n < 1$.

Try $n = \frac{1}{2}$, $T = k\sqrt{M}$, $k = \frac{T}{\sqrt{M}} \approx 1.3, 1.3, 1.3, 1.4, 1.3, 1.4$

Within the margin of error, the relationship is $T \approx 1.3\sqrt{M}$ where T is in seconds and M is in kg.

Q20e A straight line can also be fitted to the data across all the error bars. By adding more data and extending the mass range the curve can be made more pronounced and thus a linear relationship can be eliminated.

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re mathematical or conceptual errors