P Σ Λ K

PHYSICS MOCK EXAM

NESA Number

2020 HIGHER SCHOOL CERTIFICATE EXAMINATION

Physics

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue pen
- Draw diagrams using pencil
- Calculators approved by NESA may be used
- Write your NESA number where required

Total marks: 100

Section I – 20 marks (pages 2-7)

- Attempt Questions 1-20
- Allow about 35 minutes for this section

Section II – 80 marks (pages 8-22)

- Attempt Questions 21-35
- Allow about 2 hours and 25 minutes for this section

Section I: Multiple Choice Questions (20 marks)
Attempt Questions 1 – 20
Allow about 35 minutes for this part

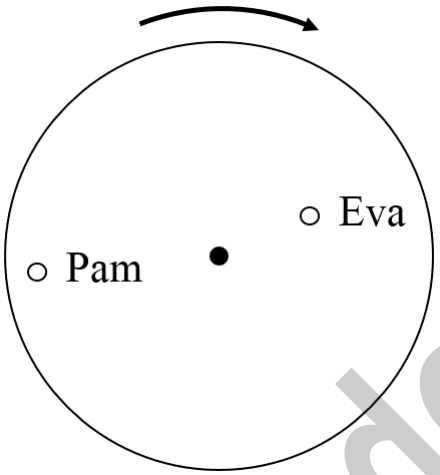
Use the multiple choice answer sheet for Questions 1 – 20.

1.	(A)	(B)	(C)	(D)
2.	(A)	(B)	(C)	(D)
3.	(A)	(B)	(C)	(D)
4.	(A)	(B)	(C)	(D)
5.	(A)	(B)	(C)	(D)
6.	(A)	(B)	(C)	(D)
7.	(A)	(B)	(C)	(D)
8.	(A)	(B)	(C)	(D)
9.	(A)	(B)	(C)	(D)
10.	(A)	(B)	(C)	(D)
11.	(A)	(B)	(C)	(D)
12.	(A)	(B)	(C)	(D)
13.	(A)	(B)	(C)	(D)
14.	(A)	(B)	(C)	(D)
15.	(A)	(B)	(C)	(D)
16.	(A)	(B)	(C)	(D)
17.	(A)	(B)	(C)	(D)
18.	(A)	(B)	(C)	(D)
19.	(A)	(B)	(C)	(D)
20.	(A)	(B)	(C)	(D)

1. During an experiment, a double-slit interference pattern is produced on a screen. If the screen is moved further away from the slits, the fringes will be

   (A) Closer together.
   (B) Further apart.
   (C) In the same positions.
   (D) Fuzzy and out of focus.

2. Eva and Pam stand on a rotating circular platform as shown below.



   Which of the following correctly compares the magnitude of their linear and angular velocities?

   (A) Pam has the greater linear velocity but their angular velocities are equal.
   (B) They both have equal linear and angular velocities.
   (C) They have the same angular velocity but Eva has a larger linear velocity.
   (D) Pam has a smaller angular velocity and their linear velocities are equal.

3. Mercury has a mass of 3.285×10^{23} kg and diameter of 4.8×10^{3} km. The acceleration due to gravity on its surface is

   (A) $3.8\ \mathrm{m\,s^{-2}}$
   (B) $15.2\ \mathrm{m\,s^{-2}}$
   (C) $0.95\ \mathrm{m\,s^{-2}}$
   (D) $7.6\ \mathrm{m\,s^{-2}}$

4. What is the role of a transformer at an electrical power station?

   (A) To reduce heating in the transmission lines by stepping up the voltage.
   (B) To reduce heating in the transmission lines by stepping up the current.
   (C) To increase heating in the transmission lines by stepping up the voltage.
   (D) To increase heating in the transmission lines by stepping up the current.

5. The orbital period and orbital radius of some planets are shown below.

Planet	Orbital Period (days)	Orbital Radius (10^6 km)
P	88	58
Q	687	228
R	59,800	4495
S	80,560	5906

Which of these planets orbit a different star to the others?

(A) P
(B) Q
(C) R
(D) S

6. A car is turning on a banked track at a constant speed. Which of the following statements is true?

(A) All the forces acting on the car are balanced, allowing it to travel at a constant speed.
(B) There is no frictional force from the road acting on the car.
(C) The force acting on the car parallel to the track is equal to the centripetal force.
(D) The net force on the car creates a centripetal force.

7. Unpolarised light of intensity I_0 is incident on two polarising sheets. At what angle should the second sheet be rotated relative to the first sheet so that the exiting light has intensity $0.25I_0$?

(A) 30°
(B) 45°
(C) 60°
(D) 90°

8. What change to the atomic model did the results of the Geiger-Marsden gold foil experiment lead to?

(A) The atom is mostly empty space.
(B) The nucleus consists of neutrons and protons.
(C) Electrons orbit the nucleus in discrete energy levels.
(D) All atoms contain positive and negative charge.

9. Which of the following is an inertial frame of reference?

(A) A lift slowing down as it reaches the bottom floor.
(B) A cyclist riding downhill without braking.
(C) A ball when it reaches its maximum height after being thrown vertically.
(D) A sky diver falling at their terminal velocity.

10. Carbon-14 has a half-life of 5730 years. How many grams of a 4.0 g sample of carbon-14 are left after 3.5 half-lives?

(A) 0.125 g
(B) 0.250 g
(C) 0.354 g
(D) 0.375 g

11. Which of the following statements regarding nuclear reactions is true?

(A) If the binding energy of the reactants is greater than that of the products, the reaction absorbs energy.
(B) If the mass of the products is greater than that of the reactants, the reaction releases energy.
(C) If the reaction is a fission reaction, the reaction releases energy because the products weigh less.
(D) If the reaction is a fusion reaction, the reaction absorbs energy because the products are more stable.

12. A new type of motor has no back EMF induced when it is running. This new motor is compared to a similar motor that does have normal back EMF. The new type of motor without back EMF would

(A) Have less torque than the normal motor.
(B) Start up faster than a normal motor.
(C) Likely burn out.
(D) Spin slower than a normal motor.

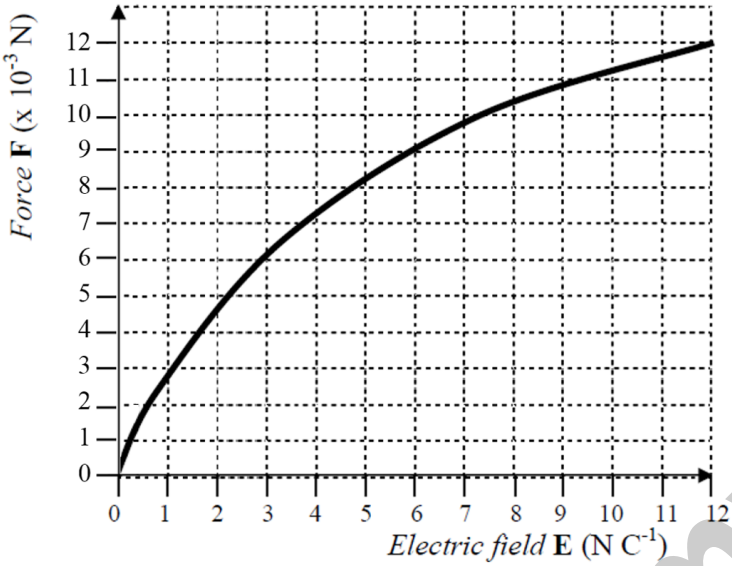
13. The principle of the conservation of energy is the reason why

(A) Transformers produce the same current in the secondary coil.
(B) Step-up transformers have a larger current in the secondary coil.
(C) Step-down transformers have a larger current in the secondary coil.
(D) Transformers are not very efficient.

14. Which of the following is a correct consequence of the speed of light in a vacuum being the same for all observers?

(A) The frame of reference of the observer is always the real frame of reference.
(B) Observations of events in distant galaxies are observations of events that occurred in the past.
(C) When measured by a stationary observer, the length of a moving object is longer than the length of the object when it is measured in its own frame of reference.
(D) A clock that is at rest in the observer's own frame of reference will tick faster than a clock that is moving relative to an observer.

15. An investigation was performed to measure the force F on a charged object as the electric field E was varied. The results were plotted on a graph of F versus E which is shown below.



Using the graph, which of the following statements is true?

(A) The magnitude of the charge was 1.0×10^{-3} C.
(B) The force was proportional to the electric field.
(C) The particle was losing charge as the electric field was strengthened.
(D) The particle was gaining charge as the electric field was strengthened.

16. Magnetic flux is most closely associated with the

(A) Number of lines of magnetic force.
(B) Density of the lines of magnetic force.
(C) Direction of the lines of magnetic force.
(D) Size of the area that the magnetic lines of force pass through.

17. A satellite of mass 845 kg moves from a low Earth orbit of altitude 2000 km to a medium Earth orbit of altitude 5000 km. Its total change in energy is:

(A) 5.07×10^{10} J
(B) -5.07×10^{10} J
(C) 5.33×10^{9} J
(D) -5.33×10^{9} J

18. Which of the four fundamental forces is not described by the Standard Model of matter?

(A) Gravitational
(B) Electromagnetic
(C) Strong
(D) Weak

19. Students are conducting a photoelectric effect experiment. They shine light of known frequency onto a metal and measure the maximum kinetic energy of the emitted photoelectrons.

The students increase the intensity of the incident light. The effect of this increase would most likely be

(A) lower maximum kinetic energy of the emitted photoelectrons.
(B) higher maximum kinetic energy of the emitted photoelectrons.
(C) fewer emitted photoelectrons but of higher maximum kinetic energy.
(D) more emitted photoelectrons but of the same maximum kinetic energy.

20. Which one of the following statements about systematic and random errors is correct?

(A) Random errors can be reduced by repeated readings.
(B) Both random and systematic errors can be reduced by repeated readings.
(C) Systematic errors can be reduced by repeated readings.
(D) Neither systematic nor random errors can be reduced by repeated readings.

Section II: Short Answer Questions (80 marks)
Attempt Questions 21 – 35
Allow about 2 hours and 25 minutes for this part

Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.

Show all relevant working in questions involving calculations.

Question 21 (5 marks)

(a) Describe in detail an experiment providing evidence for time dilation. **3**

.....

.....

.....

.....

.....

.....

.....

.....

.....

(b) Alice is on a spherical spaceship travelling at 200 000 km/s past Earth. Describe the shape of the spaceship to an observer on Earth, including relevant calculations. **2**

.....

.....

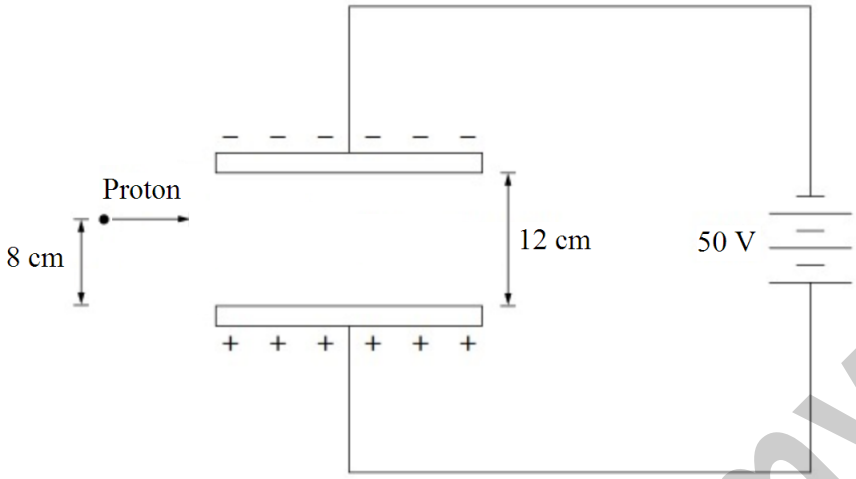
.....

.....

.....

Question 22 (5 marks)

A proton is projected horizontally between a pair of parallel plates as shown in the diagram below. The proton enters the electric field at a speed of 2×10^4 ms^{-1} and later hits one of the plates.



(a) Calculate the work done on the proton by the electric field. **2**

.....

.....

.....

.....

.....

.....

.....

(b) Calculate the final velocity of the proton. **3**

.....

.....

.....

.....

.....

.....

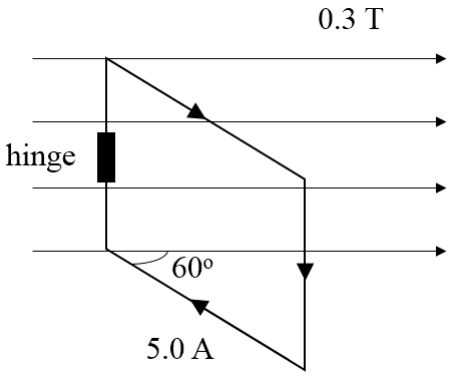
.....

.....

.....

Question 23 (4 marks)

A 20 x 20 cm square loop of wire is immersed in a magnetic field of strength 0.3 T to the right. The loop is hinged on its left side and carries a current of 5.0 A. The angle between the plane of the loop and the magnetic field is 60°.



(a) Calculate the torque acting on the loop. **2**

.....

.....

.....

.....

.....

.....

(b) The current in the loop is turned off. The loop is now rotated about its hinge by 90° anticlockwise from a top view. If this rotation occurs over 0.4 seconds, what is the average emf induced in the loop? **2**

.....

.....

.....

.....

.....

Question 24 (5 marks)

"One of the most significant discoveries in physics was Maxwell's discovery of the laws of electromagnetism." **5**

Evaluate this statement with reference to Maxwell's contribution to the classical theory of electromagnetism.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Question 25 (4 marks)

A scientist is investigating the escape velocity of an electron from a proton. It is known that the potential energy of a charge q in the presence of another charge Q a distance r away is given by

$$U_E = \frac{1}{4\pi\epsilon_0}\frac{qQ}{r}$$

(a) Calculate the minimum velocity required for an electron orbiting a proton at a radial distance of 9×10^{-15} m to escape from the proton. **2**

.....

.....

.....

.....

.....

.....

.....

(b) Explain why an electron orbiting a proton at a radial distance of 5×10^{-15} m can never escape from the proton. **2**

.....

.....

.....

.....

Question 26 (4 marks)

An astronomer observes the spectra of two stars in the sky, star X and star Y. It is known that X travels toward the Earth while Y travels away from Earth. It is also known that the rotational velocity of star X is significantly greater than that of star Y.

(a) Compare the expected spectral lines of stars X and Y. **2**

.....

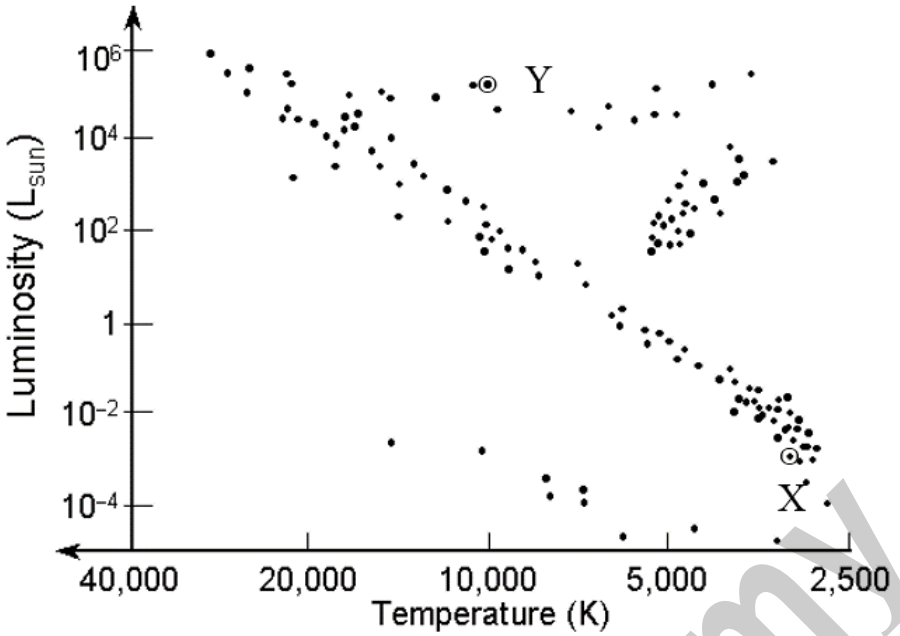
.....

.....

.....

.....

(b) The location of stars X and Y on the Hertzsprung-Russell diagram are shown below. **2**



Identify the possible nuclear reactions occurring in stars X and Y.

.....

.....

.....

.....

.....

Question 27 (8 marks)

(a) Describe how Millikan's oil drop experiment and ONE other experiment advanced scientific understanding of the electron. **4**

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(b) An oil droplet suspended between a pair of vertical parallel plates has a diameter and density of 0.24 mm and 886 kg/m^3 respectively. The plates are supplied with 220 V and are separated by 4 mm. Calculate the net charge of the oil droplet. **4**

.....

.....

.....

.....

.....

.....

.....

.....

Question 28 (5 marks)

Various methods have been used in the past to measure the speed of light.

(a) Describe one historical and one contemporary method that has been used to measure the speed of light. **4**

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(b) Today, the speed of light has been declared to be 299 792 458 m/s. Explain how this has been used to define units of measurement. **1**

.....

.....

.....

Question 29 (3 marks)

Explain how elements can be identified by spectroscopy, making reference to Bohr's model of the atom. **3**

.....

.....

.....

.....

.....

.....

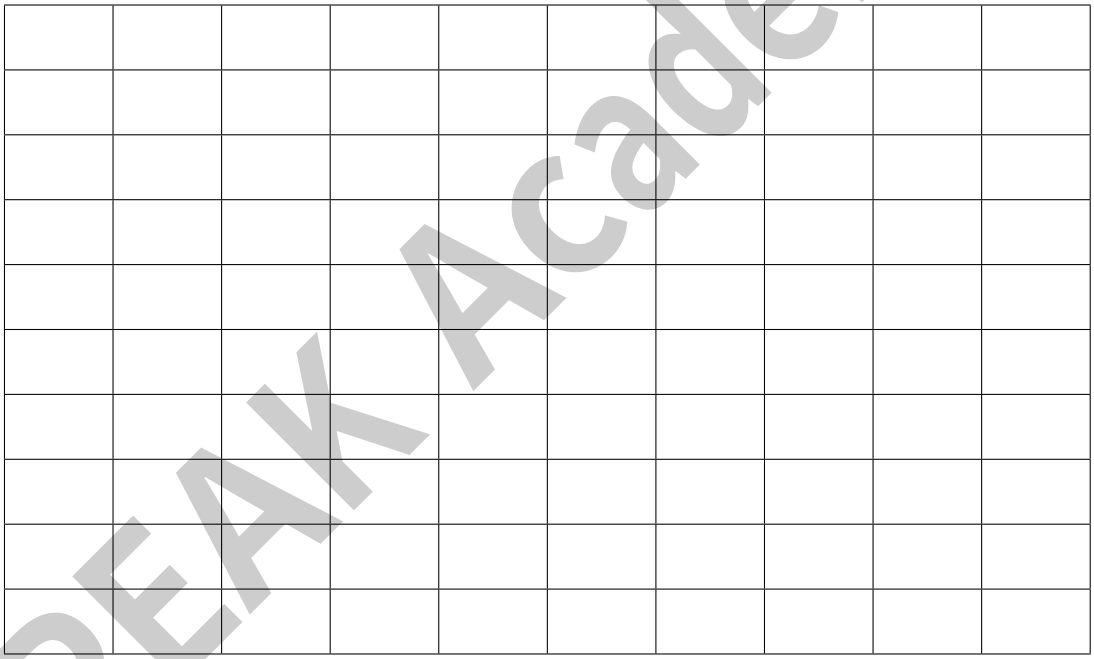
.....

Question 30 (9 marks)

A student conducted an experiment where they measured the maximum height achieved by launching an object upwards at different speeds. Their results are shown below.

Launch speed (ms^{-1})	Height (cm)
1.5	11
2.5	32
3.0	46
3.5	63
4.0	82

(a) On the grid below, plot the data so that the acceleration due to gravity can be obtained from the gradient. **3**



(b) From the graph, calculate the acceleration due to gravity. **2**

.....

.....

.....

.....

.....

(c) The student wishes to launch a projectile with a maximum height of 3.5 m and a range of 5 m. What is the required launch speed? **4**

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Question 31 (4 marks)

In his doctoral thesis, Louis de Broiglie proposed an unconventional view of the nature of electrons and particles.

(a) State de Broglie's proposal. **1**

.....

.....

.....

(b) Describe the experimental evidence for de Broglie's proposal. **3**

.....

.....

.....

.....

.....

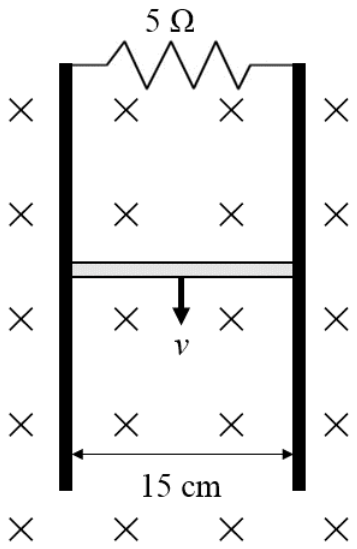
.....

.....

.....

Question 32 (6 marks)

A horizontal rod of length 15 cm and mass 100 g falls from rest along a pair of long vertical conductive rails. The rails are joined by a 5 Ω resistor as shown in the diagram below. A magnetic field of 2.0 T points into the page.



Assume that air resistance is negligible.

(a) When the rod is released, it speeds up with decreasing acceleration until it reaches a constant velocity. Explain this observation, making reference to any relevant physics principles. **3**

.....

.....

.....

.....

.....

.....

.....

.....

(b) Determine the final speed of the rod. **3**

.....

.....

.....

.....

.....

.....

.....

.....

.....

Question 33 (8 marks)

(a) Describe the relationship between quarks, hadrons and atomic nuclei and their formation in the early universe. **2**

.....

.....

.....

.....

.....

(b) Assess the importance of particle accelerators in testing and/or validating theories. Refer to specific examples in your answer. **6**

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Question 34 (6 marks)

Light with wavelength 300 nm is incident on a metal plate with a work function of 3.5 eV.

(a) Calculate the maximum kinetic energy of the ejected photoelectrons. **2**

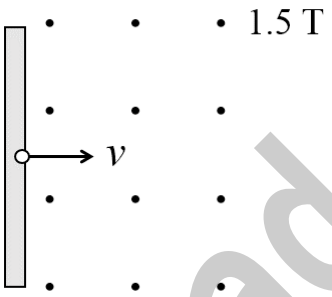
.....

.....

.....

(b) The photoelectrons are ejected into a magnetic field of strength 1.5 T pointing out of the page. The photoelectrons strike the metal plate again at a maximum distance d away from the point of ejection. **1**

On the diagram below, sketch the path of the ejected photoelectron (shown as a white circle).



(c) Calculate d. **3**

.....

.....

.....

.....

.....

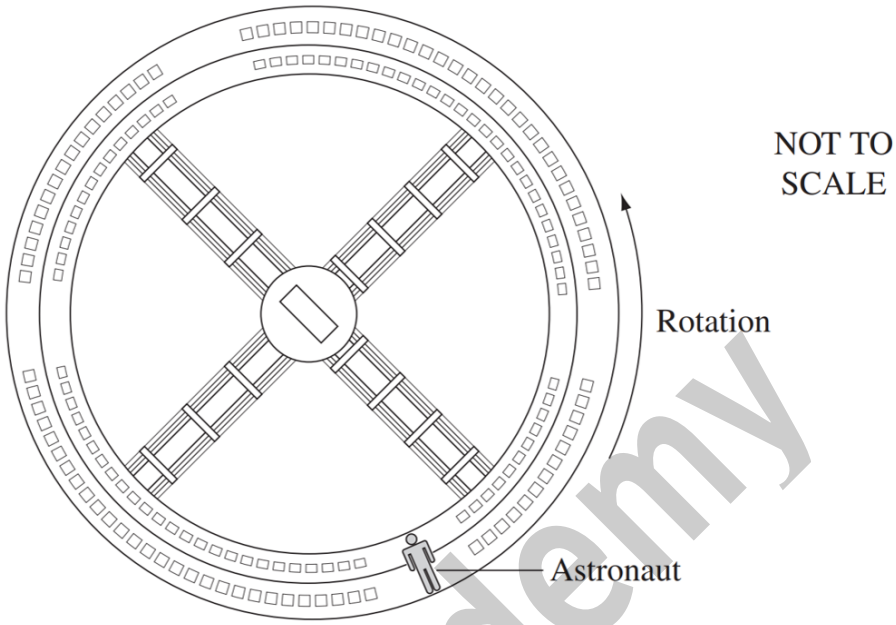
.....

.....

.....

Question 35 (4 marks)

The diagram shows a futuristic space station designed to simulate gravity in a weightless environment.



(a) Explain how rotating the space station simulates gravity for the astronaut. **2**

.....

.....

.....

(b) Calculate the angular velocity that a space station with a diameter of 550 m would need for astronauts to experience 1 g of acceleration. **2**

.....

.....

.....

.....

.....

.....

.....

.....

End of paper

PEM

2020 Trial HSC Physics Marking Guidelines

Section I, Part A

Multiple-choice Answer Key

Question	Answer
1	C
2	B
3	C
4	D
5	A
6	A
7	D
8	B
9	A
10	A
11	C
12	C
13	D
14	A
15	B
16	B
17	D
18	D
19	A
20	C

Section I, Part B

Question 21 (a)

Criteria	Marks
Correctly determines design speed.	2
Attempts to derive correct equation	1

Sample answer:

$v = \sqrt{\tan\theta\ gr}$

$v = \sqrt{\tan 15 \times 9.8 \times 30}$

$v = 8.88$ m s^{-1}

Question 21 (b)

Criteria	Marks
Calculates correct friction force down the slope	3
Calculates x component of friction force	2
Calculates the difference in centripetal force	1

Sample answer:

$F_{c2} = \frac{mv_2{}^2}{r}$ $\qquad$ $F_{c1} = \frac{mv_1{}^2}{r}$

$F_{c2} = \frac{1000 \times 13.9^2}{30}$ $\qquad$ $F_{c1} = \frac{1000 \times 8.9^2}{30}$

$F_{c2} = 6417$ N $\qquad$ $F_{c1} = 2626$ N

The difference in centripetal force is the horizontal force provided by the friction.

$\Delta F_c = F_{c2} - F_{c1}$

$\Delta F_c = 3792$ N

$f = \frac{\Delta F_c}{\cos 15}$

$f = \frac{3792}{\cos 15}$

$f = 3926$ N down the slope

Question 22 (a)

Criteria	Marks
Calculates the height of the fence correctly	3
Calculates the change in vertical displacement	2
Shows relevant working out	1

Sample answer:

$\Delta x = u_x t$

$t = \frac{\Delta x}{u \cos \theta}$

$t = \frac{74}{28 \cos 35}$

$t = 3.27$ s

$\Delta y = u_y t + \frac{1}{2} a t^2$

$\Delta y = (28 \sin 35 \times 3.27) - 4.9(3.27)^2$

$\Delta y = 0.81$ m

$h_f = \Delta y + 1.1$

$h_f = 1.92$ m

Question 22 (b)

Criteria	Marks
Calculates correct speed	2
Calculates correct y component of the speed	1

Sample answer:

$v_y = u_y + at$

$v_y = 16.1 - 9.8 \times 3.27$

$v_y = -15.6 \text{ m s}^{-1}$

$v = \sqrt{{v_y}^2 + {v_x}^2}$

$v = 27.7 \text{ m s}^{-1}$

Question 23 (a)

Criteria	Marks
Calculates applied force correctly	3
Calculates perpendicular force correctly	2
Calculates perpendicular force with incorrect radius value	1

Sample answer:

$\Sigma\tau = 0 = \tau_{F\perp} + \tau_g$

$F_\perp r = -mgr$

$F_\perp \frac{0.5}{\cos 20} = 60 \times 90 \times \frac{0.1}{\cos 20}$

$F_\perp = 117.6$

$F = \frac{F_\perp}{\cos 40}$

$F = 153.5 \text{ N}$

Question 23 (b)

Criteria	Marks
Identifies two modifications that will decrease the force	1

Sample answer:

The man could hold the wheelbarrow arm further from the pivot point or increase the angle between the wheelbarrow arm and the horizontal.

Question 24 (a)

Criteria	Marks
Calculates correct altitude of satellite	3
Calculates correct radius of orbit	2
Attempts to use Kepler's third law	1

Sample answer:

$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$

$r = \sqrt[3]{\frac{6.67\times10^{-11}\times6\times10^{24}\times86400^2}{4\pi^2}}$

$r = 4.2 \times 10^7$ m

$Altitude = r - r_{earth}$

Question 24 (b)

Criteria	Marks
Calculates correct energy	3
Calculates kinetic and gravitational potential energy	2
Attempts to use relevant equations	1

Sample answer:

$E = -\frac{GMm}{2r}$

$E = -9.46 \times 10^{9}$ J

Question 25 (a)

Criteria	Marks
Correctly calculates time	1

Sample answer:

$s = \frac{d}{t}$

$t = \frac{d}{s}$

$t = \frac{2}{5 \times 10^{7}}$

$t = 4 \times 10^{-8}$ s

Question 25 (b)

Criteria	Marks
Correctly calculates the voltage	4
Attempts to substitute correct formulae to determine the acceleration of the electron AND/OR the voltage supplied	2-3
Attempts to provides relevant information	1

Sample answer:

$s = ut + \frac{1}{2}at^2$

$-0.005 = \left(\frac{1}{2}\right)(a)(4 \times 10^{-8})^2$

$a = -6.25 \times 10^{12}$ m s^{-1}

$F = qE$

$a = \frac{F}{m}$

$a = \frac{qE}{m}$

And $E = \frac{V}{d}$

So $a = \frac{qV}{dm}$

$\therefore V = \frac{dam}{q}$

$V = \frac{(0.02)(-6.25\times10^{12})(9.109\times10^{-31})}{-1.602\times10^{-19}}$

$V = 0.71$ V

Question 26

Criteria	Marks
Demonstrates a sound understanding of the physics principles involved in a motor and a generator AND considers the energy changes and relates these to the motion of the vehicle both in propulsion and in braking AND clearly explains the physics principles involved in the propelling and braking of the vehicle	4
Demonstrates an understanding of the physics principles involved in a motor and a generator AND describes relevant energy changes	3
Demonstrates an understanding of the physics principles involved in a motor or generator OR shows some understanding of how a motor can act as a generator	2
Identifies some relevant information	1

Sample answer:

When acting as a motor, the vehicle converts electrical energy to kinetic energy due to the motor effect, thus propelling the vehicle. A motor consists of a rotating coil in a magnetic field.

When power is cut, the rotating coil in the magnetic field induces an emf to due to a change in magnetic flux. This allows the motor to act as a generator, which has essentially the same parts as a motor. When it acts as a generator, kinetic energy is converted to electrical energy, and so by Lenz's law, the motion of the rotor is opposed. This acts to slow the vehicle.

Question 27 (a)

Criteria	Marks
Correctly calculates the current	3
Attempts to substitute into correct formulae to determine the upward force required on wire 2 AND/OR the current through wire 2	1-2

Sample answer:

$mass\ of\ wire\ 2 = 0.45$ kg

$W = mg$

$W = 0.45 \times 9.8$

$W = 4.41$ N

If the reading is 0.2 kg

Then $W = 0.20 \times 9.8$

$W = 1.96$ N

$Upward\ force = 4.41 - 1.96$

$Upward\ force = 2.45$ N

$\frac{F}{l} = \frac{\mu_0}{2\pi}\frac{I_1 I_2}{r}$

$\frac{2.45}{1.5} = \frac{4\pi \times 10^{-7}}{2\pi} \times \frac{6 \times I_2}{0.025}$

$1.63 = 4.8 \times 10^{-5} \times I_2$

$I_2 = 34027$ A to the left

Question 27 (b)

Criteria	Marks
Explains the relationship between current carrying wire AND magnetic field produced AND induced current in the coil according to Lenz's Law.	3
Explains the relationship between current carrying wire AND/OR magnetic field produced AND/OR induced current in the coil according to Lenz's Law.	2
Attempts to explain any relevant information.	1

Sample answer:

When wire 2 is turned on there is an increase in magnetic flux through the coil and into the page. This is because a magnetic field flows around a current carrying conductor. An emf is induced in the coil to oppose this rate of change of flux (Lenz's Law).

Question 27 (c)

Criteria	Marks
Correctly indicates direction on coil	1

Sample answer:

This induced emf will be in a clockwise direction.

Question 28 (a)

Criteria	Marks
Correctly calculates the torque (clockwise)	2
Attempts to substitute correct information into a relevant equation	1

Sample answer:

$\tau = nIA_{\perp}B$

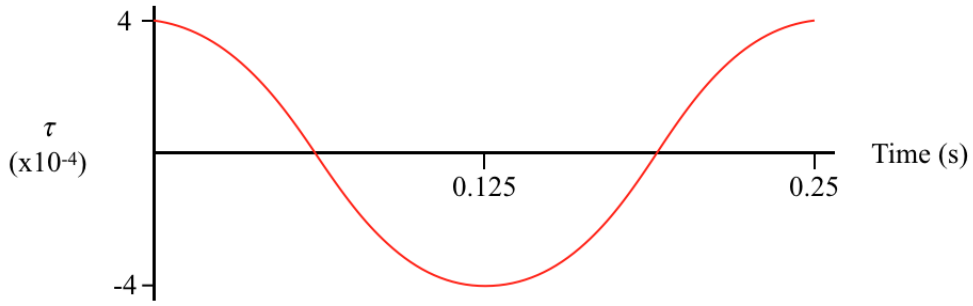
$\tau = 3 \times 0.0009 \times 0.15$

$\tau = 4.05 \times 10^{-4}$ Nm

Question 28 (b)

Criteria	Marks
Graph correctly drawn including correct scale on both axes	2
As above with error or exclusion	1

Sample answer:



Question 29 (a)

Criteria	Marks
Identifies correct error type. Human error not an error type.	1

Sample answer:

Observational systematic error.

Question 29 (b)

Criteria	Marks
Calculates correctly Galileo's fastest possible speed measurement showing correct working	3
Calculates the correct speed but does not include the time taken for light in working	2
Correctly calculates the time light would take to travel 2 km	1

Sample answer:

$t = \frac{2d}{c}$

$t = \frac{2\times1000}{3\times10^8} = 7 \times 10^{-6}$ s

$v = \frac{2d}{t}$

$v = \frac{2\times1000}{7\times10^{-6}+0.5}$

$v = 4000$ m s^{-1-}

Question 29 (c)

Criteria	Marks
Makes a judgment of the validity based on the predicted measurement from the previous answer.	3
Makes a judgment of the validity	2
Provides relevant information in regard to validity	1

Sample answer:

Comparing the above value to the known value of the speed of light Galileo's result would have been wildly inaccurate. Due to the incredibly fast speed of light the time it took light to travel 2 km was an insignificant amount of time compared to the reaction time. His method therefore could not practically measure the speed of light. It therefore was a very invalid method as it cannot fulfil the aim.

Question 30

Criteria	Marks
• Describes three models of light over time • Describes new evidence and explains why it necessitated change to a new model • Answer is coherent, logical and sequential	3
• Describes three models of light over time • Describes new evidence and explains why it necessitated change to a new model	5-6
• Describes two models of light over time • Describes new evidence and explains why it necessitated change to a new model	3-4
• Describes one models of light and Describes new evidence and explains why it necessitated change to a new model	1-2

Sample answer:

Isaac Newton's particle model of light described light made of corpuscles which varied in size depending on the colour of the light. In the 18th century, young's double slit experiment showed that light diffracts when passing through a slit. This was evident in the interference patterns produce which are consistent with wave nature. This supported a wave model of light and thus Newton's particle model was replaced with the classical wave model.

In the 19th century the photo-electric effect was observed and was not explainable using the classical model of light. The photo-electric effect is the emission of electrons from a metal when light above a certain frequency is incident upon the metal. A classical model would suggest that intensity, not frequency, is relate to electron ejection. Also, electron emission was almost spontaneous, where the classical wave model would predict that emission should occur after some time so as to allow energy to build up.

In 1905, Albert Einstein was able to explain the photo-electric effect by using a particle model of light, where light was made up of packets of energy called photons. These photons would collide with electrons and would eject the electrons if they possessed enough energy, where energy is proportional to frequency.

The new evidence supported the particle model of light but since a wave model was appropriate to describe other light phenomenon, such as diffraction, a new particle-wave model was adopted. This model indicates that light can behave as both a particle and a wave depending on the scenario. Thus, over time the emergence of new evidence regarding the nature of light has forced the scientific community to continually reassess the model of light.

Question 31 (a)

Criteria	Marks
Describes absorption and emission spectra production and how they are similar.	3
Describes absorption and emission spectra production	2
Describes absorption or emission spectra production	1

Sample answer:

Both the absorbed and emitted lines correspond to the electron energy levels of atoms. Photons of precise frequency/wavelength corresponding to those energy levels are absorbed or emitted.

Absorption spectra are produced when a continuous spectrum of light passes through a cloud of cool gas, such as in stars. Atoms in the gas absorb photons of wavelength corresponding to the quanta of energy involved in possible transitions of electrons to higher energy levels. The wavelengths correspond to the dark lines of the absorption spectrum.

The coloured lines in the emission spectra are produced by photons being emitted by electrons from 'excited' atoms as they fall from higher energy levels. Each 'fall' involves a precise 'quantum' of energy, which produces a precise frequency and wavelength.

Question 31 (b)

Criteria	Marks
Explains unique energy levels of atoms and therefore spectra to analyse chemical composition	3
Describes unique spectra of elements to identify chemical composition	2
Identifies unique spectra of elements	1

Sample answer:

Lines produced in absorption and emission spectra are characteristic of the atoms that were heated or that light passed through. Every element has different energy levels to which electrons can move to. This corresponds to photons with different frequencies/wavelengths. Because no two elements produce the same spectrum and all atoms of the same element produce the same spectrum, the chemical composition can be deduced from analysing spectra.

Question 32

Criteria	Marks
Provides correct characteristics and features of two theories proposed by two scientists AND correctly relates one of these theories to the experimental evidence that supports the statement.	5-6
Provides correct characteristics and features of one OR two theories proposed by two scientists AND/OR correctly relates one of these theories to the experimental evidence that supports the statement.	3-4
Provides relevant information related to the theory of the scientists AND/OR provides relevant information related to a relevant experiment	2
Provides relevant information related to the theory of the scientists OR provides relevant information related to a relevant experiment	1

Sample answer:

The failure of classical Physics to adequately explain blackbody radiation, the photoelectric effect and the hydrogen atom ultimately demolished the foundations of classical Physics.

Max Planck explained the deviation of experiment to classical prediction for blackbody radiation. This is known as the left-hand catastrophe. He stated that the energy of electrons comes in clumps – he named a clump of energy a quantum.

Louis de Broglie proposed that wave-particle duality not only applied to light (as described by Einstein) but to everything in nature. De Broglie rewrote Einstein's equation. The evidence that electrons propagate like a wave came when electrons were passed through a double slit and counted as they hit a screen. If the electrons travelled like a stream of particles, they would have simply piled up at two locations behind the two slits. But they didn't. They showed a double-slit interference pattern, bright bands and dark bands just like the ones produced by light waves. Davisson and Germer experimentally confirmed de Broglie's prediction in 1927 when they bombarded the surface of a piece of nickel with electrons which were then scattered and detected by a moveable electron detector. They found the electrons were interfering with one another to produce a diffraction pattern. This evidence was ground-breaking in that it showed the limitations of classical physics in describing the nature of moving particles.

Question 33

Criteria	Marks
Correctly calculates the binding energy of $^{7}_{4}Be$ in MeV	2
Attempts to calculate binding energy using any correct method	1

Sample answer:

$^{7}_{4}Be$ has 4 protons and 3 neutrons

$mass\ defect = (3 \times 1.675 \times 10^{-27}) + (4 \times 1.673 \times 10^{-27}) - (1.16519 \times 10^{-26})$

$mass\ defect = 6.51 \times 10^{-29}$ kg

$E = mc^2$

$E = 6.51 \times 10^{-29} \times (3 \times 10^{8})^2$

$E = 5.859 \times 10^{-12}$ J

$E = \frac{5.859 \times 10^{-12}}{1.602 \times 10^{-19}}$

$E = 36573033.71$ eV

$E = 36.573$ MeV

Question 34

Criteria	Marks
Correctly calculates the initial energy level (n=6)	3
Substitutes correct information into the Rydberg equation.	2
Attempts to substitute the correct information into the Rydberg equation	1

Sample answer:

$\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{{n_i}^2}\right)$

$\frac{1}{410.1\times10^{-9}} = 1.097 \times 10^7 \left(\frac{1}{4} - \frac{1}{n^2}\right)$

$\frac{1}{410.1\times10^{-9}} = 2742500 - \frac{1.097\times10^7}{n^2}$

$\frac{1.097\times10^7}{n^2} = 2742500 - \frac{1}{410.1\times10^{-9}}$

$\frac{1.097\times10^7}{n^2} = 304070$

$\frac{n^2}{1.097\times10^7} = \frac{1}{304070}$

$n = \sqrt{\frac{1.097\times10^7}{304070}}$

$n = 6$

Question 35

Criteria	Marks
• Provides detailed descriptions of the correct nucleosynthesis reactions occurring at all three star types • Relates mass to dominant nucleosynthesis reaction and position on the diagram • Thoroughly compares the nucleosynthesis reactions of main sequence stars with the reactions occurring within Giant and super giant stars. • Answer is logical, coherent, and well structured	7-9
3 of the above	4-6
Provides some relevant information	1-3

Sample answer:

There are three main nucleosynthesis reactions occurring in the core of main sequence stars; Proton-proton chain, CNO cycle and the Triple Alpha process.

The Proton-proton chain fuses four protons to form one helium nucleus plus energy. The CNO cycle fuses four protons with larger nuclei to form one helium nucleus plus energy. The triple alpha process fuses helium nuclei with increasingly large nuclei up to oxygen.

All three of the nucleosynthesis reactions follow a series of reactions shown below.

P-P chain	**CNO cycle**	**Triple Alpha**
${}_1^1H + {}_1^1H \rightarrow {}_2^2He$	${}_6^{12}C + {}_1^1H \longrightarrow {}_7^{13}N + \gamma$	${}_2^4He + {}_2^4He \longrightarrow {}_4^8Be + \gamma$
${}_2^2He \rightarrow {}_1^2H + {}_1^0e + \upsilon$	${}_7^{13}N \rightarrow {}_6^{13}C + {}_1^0e + \upsilon$	${}_4^8Be + {}_2^4He \longrightarrow {}_6^{12}C + \gamma$
${}_1^2H + {}_1^1H \rightarrow {}_2^3He + \gamma$	${}_6^{13}C + {}_1^1H \rightarrow {}_7^{14}N + \gamma$	
${}_2^3He + {}_2^3He \rightarrow {}_2^4He + {}_1^1H + {}_1^1H$	${}_7^{14}N + {}_1^1H \rightarrow {}_8^{15}O + \gamma$	
	${}_8^{15}O \rightarrow {}_7^{15}N + {}_1^0e + \upsilon$	
	${}_7^{15}N + {}_1^1H \rightarrow {}_6^{12}C + {}_2^4He$	

The ratio of these reactions is dependent on mass, as larger gravitational forces are required for the CNO cycle and even larger for the triple alpha process.

Stars are positioned on the main sequence according to their surface temperature and luminosity. Luminosity has a directly proportional relationship to mass on the main sequence, such that stars in the upper left of the HR diagram are high mass with large gravitational forces, and stars in the bottom right are small mass with relatively small gravitational forces.

Because the dominant nucleosynthesis reaction is dependent on gravitational forces the dominant reaction in the largest main sequence stars will be the CNO cycle. The ratio of CNO cycle to P-P chain reactions

decreases as the mass decreases, to a point where the dominant reaction of the bottom half of the main sequence is the P-P chain.

The dominant nucleosynthesis reaction occurring at the core of red giants is the triple Alpha reaction. The triple alpha reaction is similar to the P-P chain and CNO cycle in that it fuses smaller nuclei into larger nuclei and releases larger amounts of energy. It differs in that it produces nuclei larger than Helium up to Oxygen and requires much larger gravitational forces to sustain in large quantities. It also uses helium nuclei as the basic building block rather than hydrogen nuclei.

The dominant nucleosynthesis reaction occurring at the core of a super-giant star depends on how long it has been at this position. The core nuclei increase in size up to Iron as the star ages. The fusion of heavy nuclei is once again similar to the previously mentioned nucleosynthesis reactions in that it fuses smaller nuclei to create larger nuclei and releases energy. It differs in that it does not always use a specific small nucleus to build larger ones. Rather the gravitational forces are so large that it is able to overcome the large repulsive electric charges of two heavy nuclei and fuse them together.

Physics

2020 Trial HSC Examination Mapping Grid

Part A

Question	Marks	Outcome
1	1	PH12-15
2	1	PH12-14
3	1	PH12-15
4	1	PH12-13
5	1	PH12-12
6	1	PH12-15
7	1	PH12-15
8	1	PH12-15
9	1	PH12-13
10	1	PH12-13
11	1	PH12-13
12	1	PH12-13
13	1	PH12-14
14	1	PH12-14
15	1	PH12-14
16	1	PH12-14
17	1	PH12-12
18	1	PH12-12
19	1	PH12-12
20	1	PH12-12

Part B

Question	Marks	Outcome
21 (a)	2	PH12-12
21 (b)	3	PH12-12
22 (a)	3	PH12-12
22 (b)	2	PH12-12
23 (a)	3	PH12-12
23 (b)	1	PH12-12

Question	Marks	Content
24 (a)	3	PH12-12
24 (b)	3	PH12-12
25 (a)	1	PH12-13
25 (b)	4	PH12-13
26	4	PH12-13
27 (a)	3	PH12-13
27 (b)	3	PH12-13
27 (c)	1	PH12-13
28 (a)	2	PH12-13
28 (b)	2	PH12-13
29 (a)	1	PH12-14
29 (b)	3	PH12-14
29 (c)	3	PH12-14
30	7	PH12-14
31 (a)	3	PH12-14
31 (b)	3	PH12-14
32	6	PH12-15
33	2	PH12-15
34	3	PH12-15
35	9	PH12-15