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

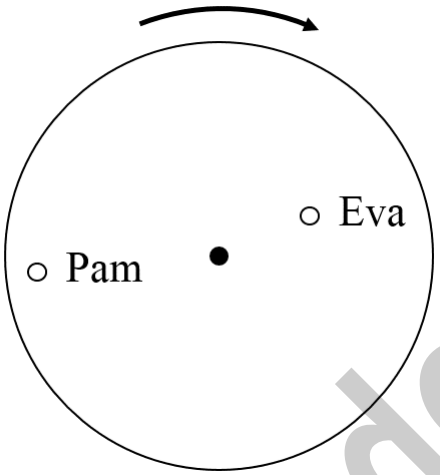
Use the multiple choice answer sheet for Questions 1 – 20.

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.

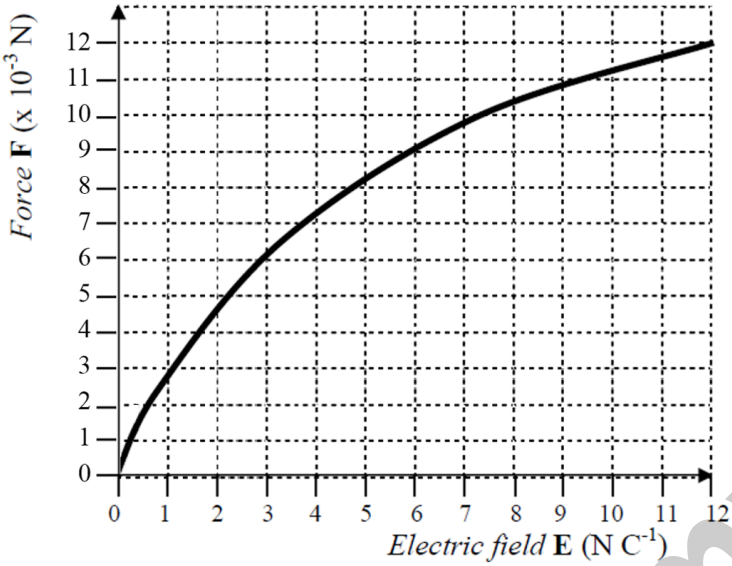
13. The principle of the conservation of energy is the reason why

(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**

.....

.....

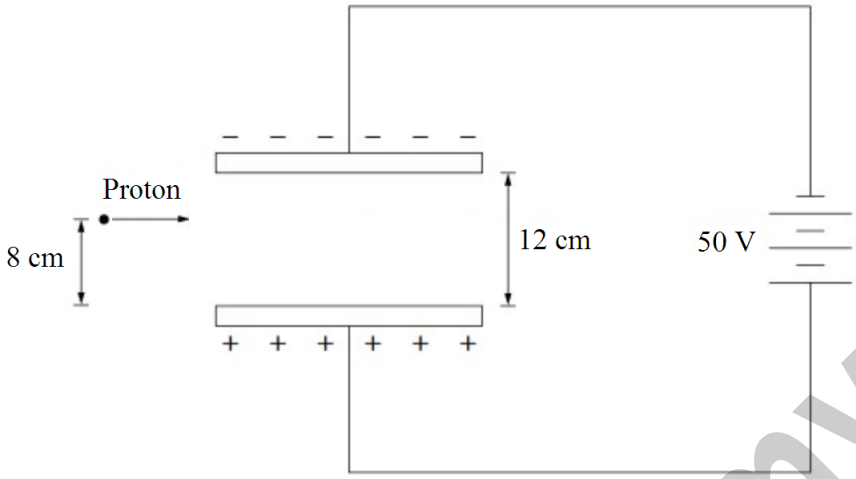
.....

.....

.....

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**

.....

.....

.....

.....

.....

.....

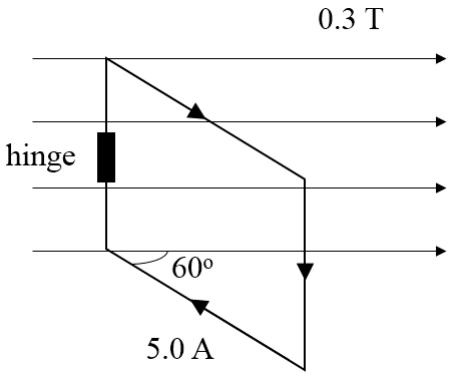
.....

.....

.....

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**

.....

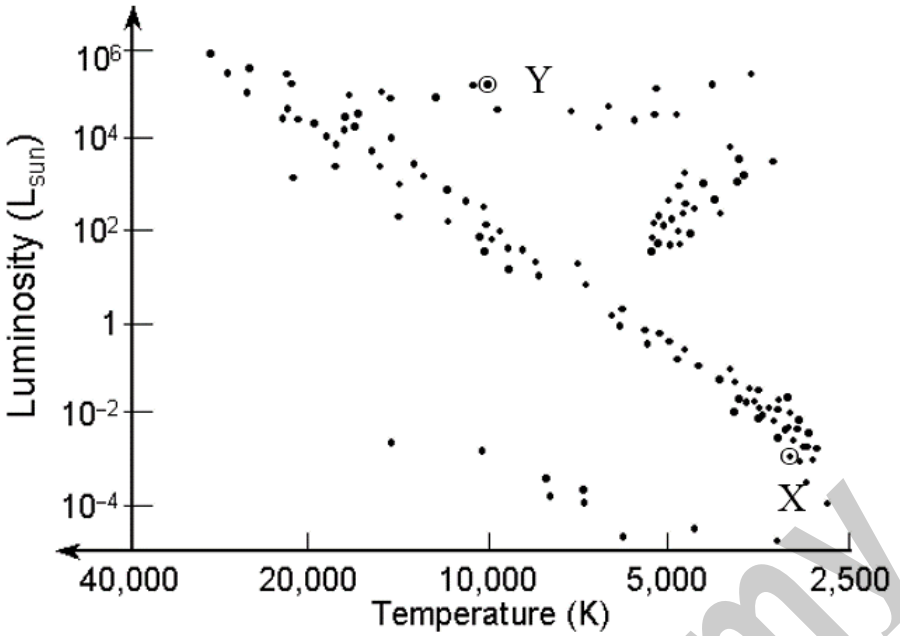
.....

.....

.....

.....

(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**

.....

.....

.....

.....

.....

.....

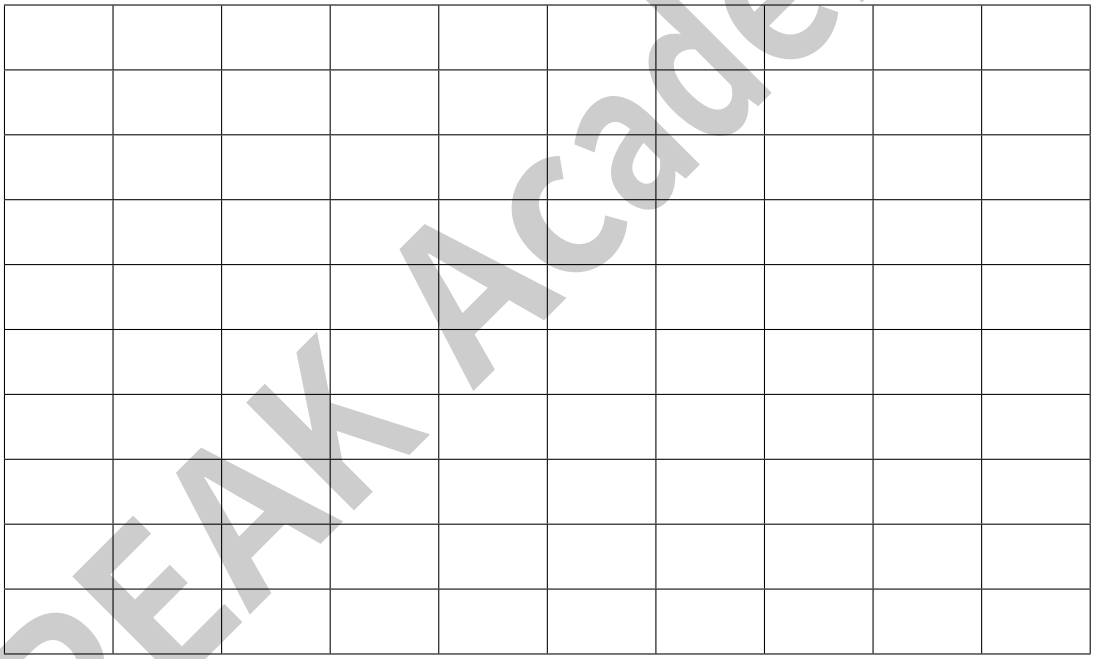
.....

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**

.....

.....

.....

.....

.....

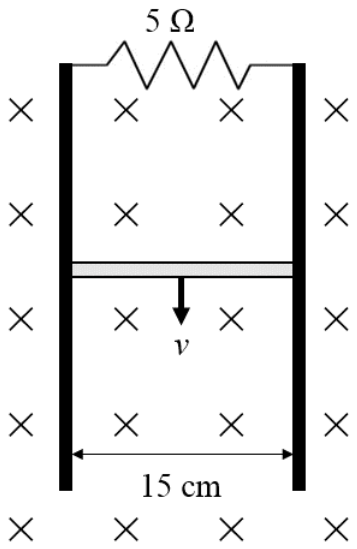
.....

.....

.....

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**

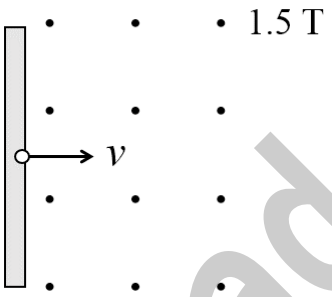
.....

.....

.....

(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**

.....

.....

.....

.....

.....

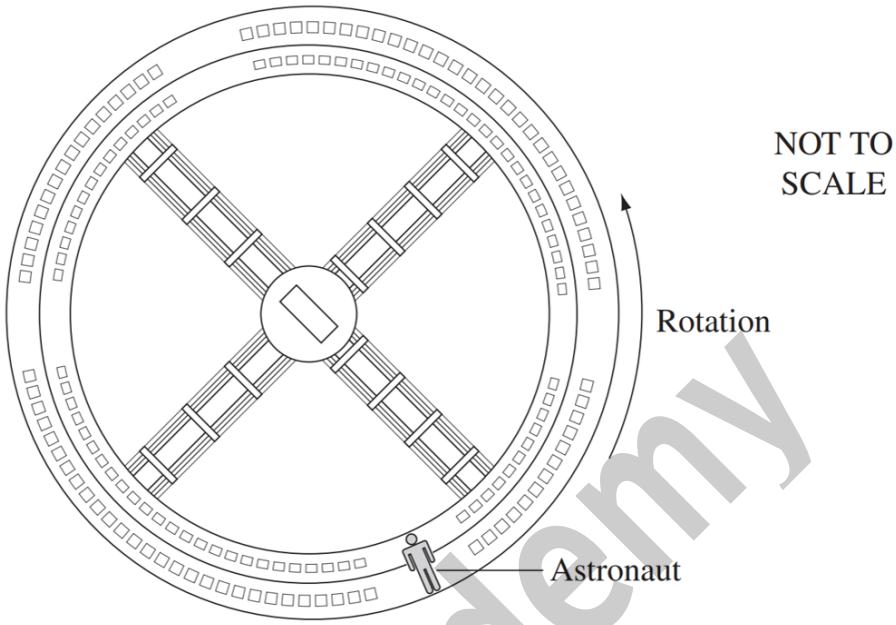
.....

.....

.....

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