Physics

Trial Examination

HSC Course

2007

General Instructions

Reading time - *5 minutes*

Working time - *2 hours 15 minutes*

Board-approved calculators may be used.

Write using blue or black pen.

Draw diagrams using pencil.

Formulae sheets and a Periodic Table are provided with this question paper.

Answer all questions in the spaces provided.

Total Marks (75)

This paper has one section with two parts:

Section I

Total marks (75)

Part A

15 marks – attempt questions 1 -15

Part B

60 marks – attempt questions 16 - 30

Section I

Total Marks (75)

Part A

Total Marks (15)

Attempt Questions 1 – 15

Allow about 30 minutes for this part

For each question place a cross (X) in the column which matches your choice.

Question	A	B	C	D
1				
2				
3				
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1. Jupiter has a gravitational acceleration equal to 2.53 times that of Earth. An object on Jupiter weighs 253 N.

   Its weight on Earth (in N) would be:

   A. 24.8 B. 98 C. 100 D. 980

2. An object is in a stable orbit around the Earth.

   Which statement about the forces acting on this object is correct?

   A. Both inertial and gravitational forces act on the object.
   B. Inertial force is the only force acting on the object.
   C. Gravitational force is the only force acting on the object.
   D. There is no net force acting on the object.

3. Two satellites are orbiting a planet. Satellite X is at an altitude of 3000 km and satellite Y is at an altitude of 6000 km.

   Which statement about X and Y is correct?

   A. X must have a smaller mass than Y.
   B. The frequency (revolutions per day) of Y will be smaller than X.
   C. X will have a smaller orbital speed than Y.
   D. The period of Y's orbit will be smaller than that of X.

4. In his first thought experiment, Einstein, imagining he was inside a train moving at the speed of light, concluded that he would see his reflection in a mirror he was holding in front of him.

   He reached this conclusion because:

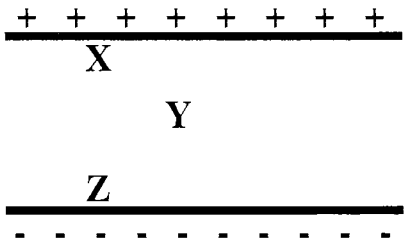
   A. he knew that the mirror was at rest relative to objects outside the train.
   B. this conclusion was consistent with the law of simultaneity.
   C. this had to be the situation if the principle of relativity was to hold true.
   D. this conclusion would make the existence of the aether unnecessary.

5. For most experimental purposes we accept the Earth as an inertial frame of reference.

   This is correct because:

   A. the velocity of the Earth is constantly changing.
   B. the Earth is moving rapidly through space.
   C. the net force acting on the Earth is zero.
   D. gravitational and centripetal forces acting on the Earth cancel each other out.

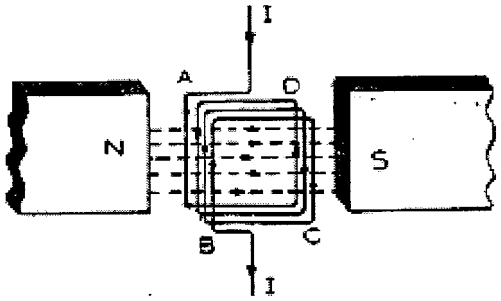
6. Two parallel metal plates carrying opposite charges are shown below.



Select the alternative which correctly describes the electric field between the plates.

A. The electric field at X is stronger than the electric fields at Y and Z.
B. The electric field at X is stronger than the electric field at Y but the same as at Z.
C. The electric field at X is weaker than the electric field at Z.
D. The electric fields at X, Y and Z are all the same strength.

7. A simple motor has a rectangular coil ABCD. The side AB measures 0.14 m and the side BC measures 0.10 m. In a magnetic field of 0.5 T, the coil experiences a torque of 0.16 Nm.



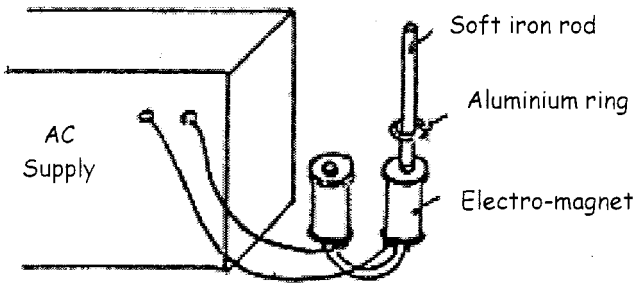
The magnitude of the force (in N) on side AB of the coil is:

A. 1.1×10^{-3} B. 3.3×10^{-3} C. 1.6 D. 3.2

8. Which of the following forms of energy is always produced whenever electricity is converted for use in the home or industry?

A. Heat
B. Light
C. Sound
D. Electromagnetic

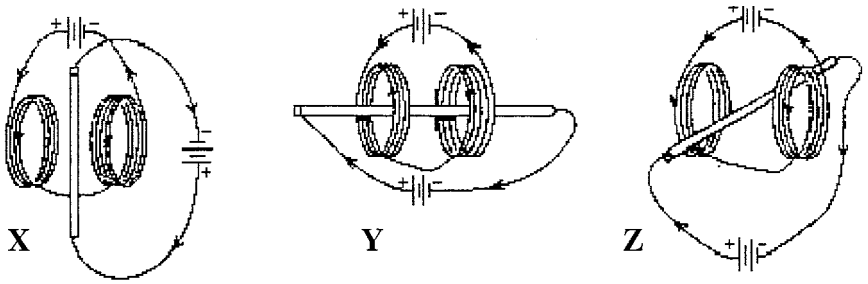
9. A student made the sketch below of an experiment demonstrated by his teacher. It appears to show a metal ring suspended on a long soft iron rod core of an electromagnet.



Select the statement which is the best explanation of the record made by the student.

A. The student's diagram has to be incorrect as aluminium rings cannot stay suspended.
B. The aluminium ring is magnetic and therefore repelled by the field of the electromagnet.
C. The aluminium ring is a superconductor and is demonstrating magnetic levitation.
D. There are eddy currents set up in the aluminium ring and their magnetic field results in repulsion by the magnetic field of the electromagnet.

10. A conductor carrying a current is placed in various orientations between two solenoids, also carrying currents as shown.



The conducting rod will experience a force in diagrams:

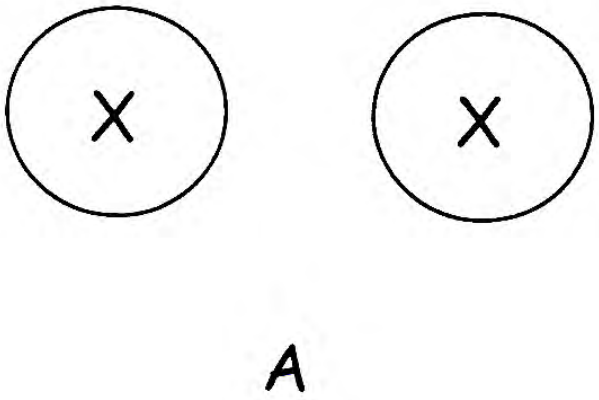
A. X and Y only
B. X and Z only
C. Y and Z only
D. Y only

11. Light of a frequency greater than the threshold frequency is incident on the surface of a piece of metal.

Select the correct statement about the ejected electrons.

A. The kinetic energy of the ejected electrons is increased if either the frequency or the intensity of the incident of the incident light is increased.
B. The kinetic energy of the ejected electrons is increased if the frequency of the incident light is increased but not changed if the intensity of the light is altered.
C. The kinetic energy of the ejected electrons is decreased if either the frequency or the intensity of the incident of the incident light is increased.
D. The kinetic energy of the ejected electrons is increased if the frequency of the incident light is increased but not changed if the frequency of the light is altered.

12. Two parallel conductors with identical currents into the page are represented below.



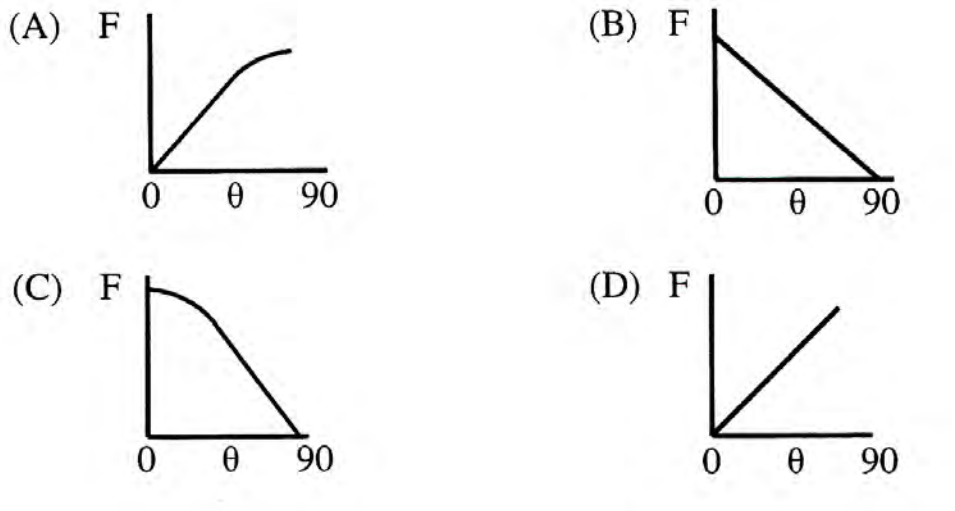
The direction of the magnetic field at A is:

A. ←
B. ↑
C. →
D. ↓

13. Which of the following items would be used inside a cathode ray tube to provide evidence for the particle nature of cathode rays?

A. Parallel charged plates
B. A maltese cross
C. Flourescent display wheel
D. Glass paddle wheel

14. A negative charge moving at a constant speed enters a magnetic field B at an angle ϑ. Which of the following represents how the force on the charge varies for values of ϑ between 0^o and 90^o?



15. Superconductivity has been demonstrated in particular metals, metal alloys and compounds. Each group of chemicals has critical temperatures in a different range.

Which alternative has the correct order for the critical temperatures of the groups, from highest to lowest?

A. metals, metal alloys, compounds
B. compounds, metal alloys, metals
C. compounds, metals, metal alloys
D. metal alloys, metals, compounds

Section I continued

Part B

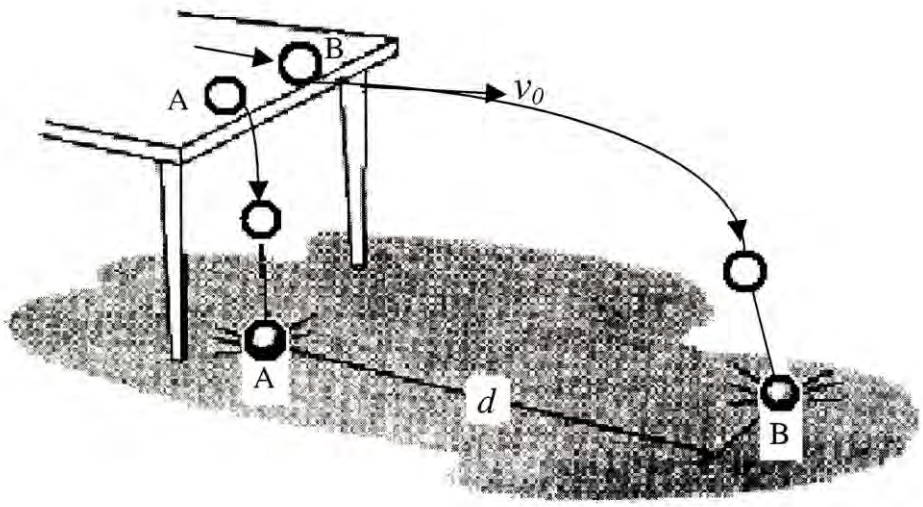
Total Marks (60)

Attempt Questions 16 – 30

Allow about 1 hour and 45 minutes for this part

Question 16 (4 marks)

Two students studying projectile motion are comparing the motion of two balls, A and B. They drop ball A from the edge of the bench, 0.90 m high, while rolling an identical ball B along the bench. The balls leave the bench at the same instant, A with zero horizontal velocity while B has a horizontal velocity of 6 ms^{-1}.



(a) Determine the extra distance, d, that ball B lands from the edge of the bench, compared to ball A. **2**

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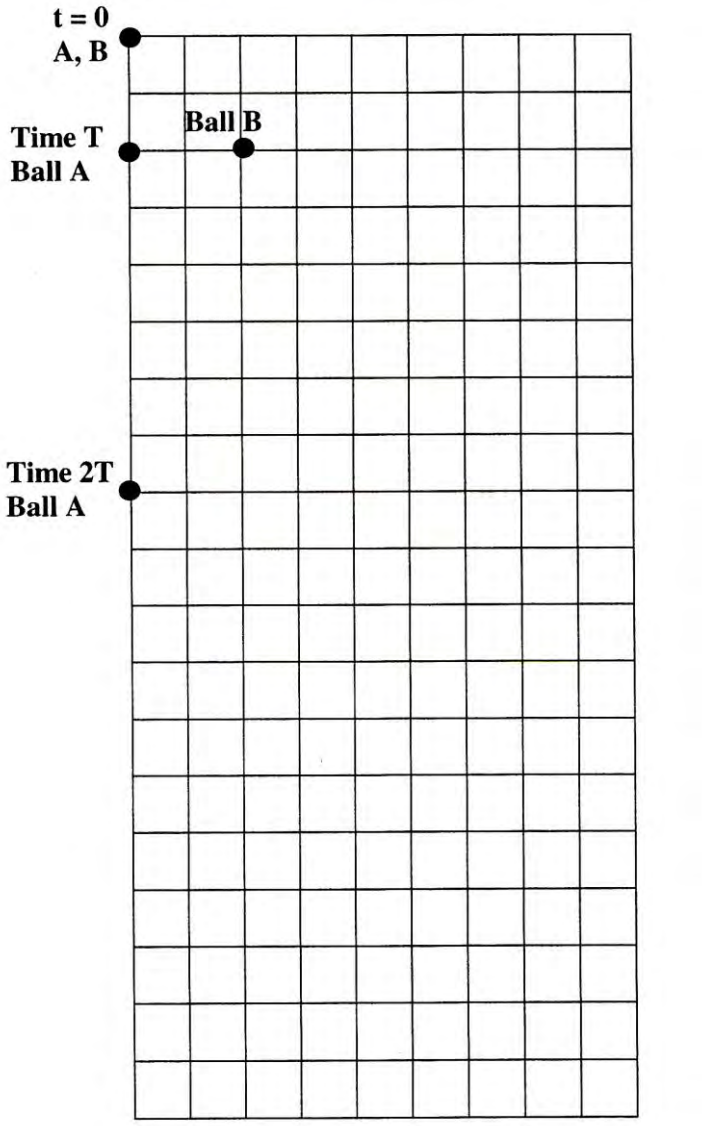
Question 16 (continued)

The students use a flashing light and a long camera exposure to photograph the falling balls. The students use the photo to draw a plot of the trajectory of the two balls. The flash rate is not known so the students label the time interval between flashes T. On the graph below, the position of ball A at t = 0 and at time T and 2T have been drawn. The position of ball B at t= 0 and at time T has been drawn.



(b) On the graph above, draw the position of ball B at time 2T. **1**

(c) On the graph above, draw the position of ball A at time 3T. **1**

Question 17 (3 marks)

(a) Explain the concept of g-force. **2**

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(b) Identify ONE strategy used during rocket take off to minimise the effect of the g-force acting on astronauts. **1**

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Question 18 (3 marks)

A satellite has a mass of 250 kg and orbits the Earth at an altitude of 3000 km. The Earth's equatorial diameter is 12 756 km.

(a) Determine its orbital speed. **2**

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(b) Compare the orbital speed of a 500 kg satellite with the speed of the 250 kg satellite in an identical orbit. **1**

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Question 19 (3 marks)

Explain the idea of the relativity of simultaneity, giving an example to support your answer. **3**

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Question 20 (4 marks)

(a) Why did early scientists propose the need for the existence of the aether? **1**

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(b) It is recognised that the Michelson-Morley experiment will always have a null result, whether or not the aether exists.

Explain this statement. **2**

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Question 21 (3 marks)

Discuss the implications of time dilation and mass increase for space travel. **3**

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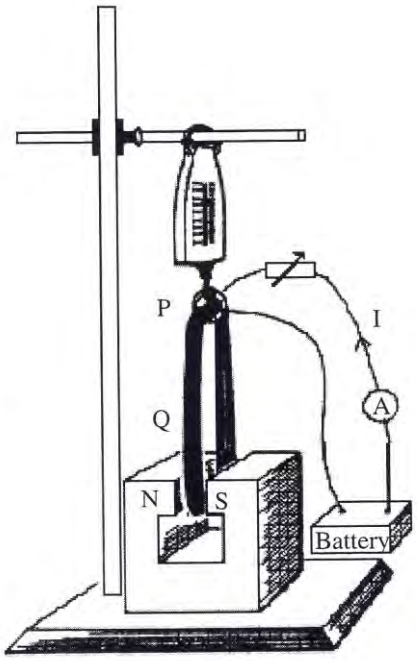
Question 22 (5 marks)

Asked to consider a model electric meter, a group of students used a spring balance and a coil of wire suspended between the poles of a horseshoe magnet as shown below. The coil had 100 turns, weighed 1.6 N and was 20 cm high and 5 cm wide. The poles of the magnet were wider than the coil and the spring balance had a scale of 0 to 5 newtons. A variable resistor and an ammeter were included in the circuit for calibration purposes.



(a) When the switch was closed, the spring balance reading increased from 1.6 N to 1.9 N when a current of 0.20 A flowed through the circuit. Calculate the magnetic field strength between the poles of the magnet. **1**

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(b) In what direction was the current flow along section PQ of the coil? **1**

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(c) Calculate the largest current that could be measured using the spring balance. **1**

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Question 22 is continued on the next page

Question 22 Continued

(d) The students stated that they could calculate the current by substituting the spring balance reading into a simple formula, provided they adjusted the position of the coil.
Justify this statement. **2**

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Question 23 (5 marks)

In the 1880s Westinghouse and Edison competed to supply electricity to cities in America until finally it was decided that alternating current provided the most efficient electricity supply.

Discuss reasons for the efficiency of alternating current in BOTH its production and transmission when compared to direct current. **5**

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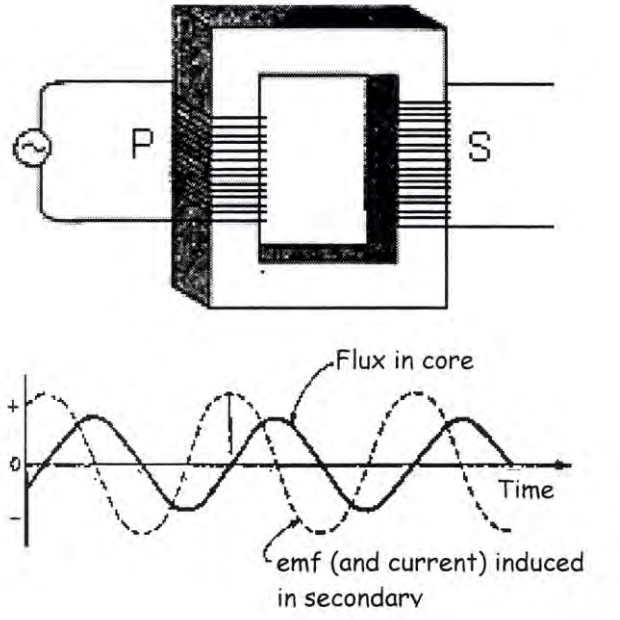
Question 24 (4 marks)

The transformer below has 14 turns in the primary coil and 28 turns in the secondary coil. The graph shows how the flux in the iron core of the transformer is related to the emf and current induced in the secondary coil.



(a) If the voltage across the secondary coil is 60 volts, calculate the input voltage. **1**

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(b) The graph shows that the emf across the secondary coil is a maximum when the flux through the iron core is zero. Explain this relationship. **1**

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(c) Explain how the heating problems of transformer cores are overcome. **2**

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Question 25 (6 marks)

Induction has many applications, being used in a number of electrical devices.

(a) Describe how an aluminium disc and a bar magnet can be used in an investigation performed in a school laboratory to demonstrate the principle of an AC induction motor. **3**

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(b) Manufacturers state that induction cook tops can only be used with saucepans made from iron and purchasers are advised to use a refrigerator magnet to test their saucepans.
Since currents can be induced in metals other than iron, discuss the reasons for designing induction cook tops that require iron based saucepans. **3**

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Question 26 (4 marks)

Explain the need for BOTH a high voltage and a lower voltage in different parts of a cathode ray oscilloscope. **4**

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Question 27 (2 marks)

State the advantages of the maglev train and explain the impact of superconductors on the development of this mode of transportation. **2**

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Question 28 (7 marks)

In the 1860s, Maxwell developed is famous equations describing the interaction of magnetic and electric fields resulting in the production of self-propagating "electromagnetic" waves.

(a) Outline the experiment performed by Hertz producing radio waves. **2**
(You may use a labelled diagram.)

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(b) Explain how Hertz confirmed that his waves were the electromagnetic waves predicted by Maxwell's equations and that they had the same properties as light. **3**

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Question 28 continues on the next page

Question 28 (Continued)

(c) Evaluate the importance of the experiments performed by Hertz to scientific theory and society. **2**

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Question 29 (3 marks)

(a) What is meant by a "black body"? **1**

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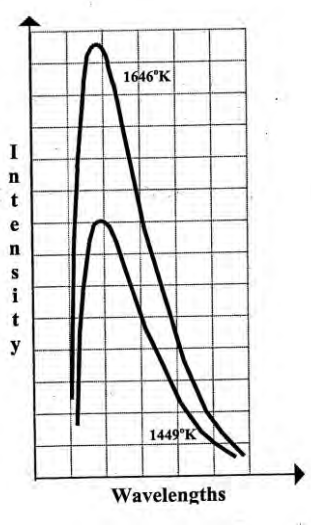
(b) The diagram below shows the shape of the curve for the intensity of thermal radiation from a black body plotted against the distribution of wavelengths at two different temperatures.



State the contribution that Planck made in his efforts to find a general formula for these curves. **2**

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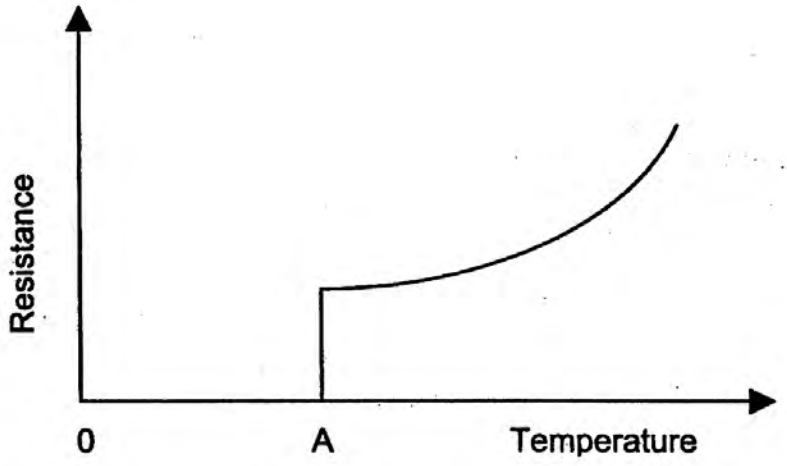
Question 30 (4 marks)

(a) Give the name for the temperature marked as "A" on the graph below, and explain its physical significance. **2**



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(b) Onnes was the first scientist to discover this behaviour.

Name the metal he used and state the temperature at which the phenomenon occurred. **1**

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(c) Since the time of Onnes discovery (1911) other materials have been discovered which also demonstrate this type of behaviour.

Outline how these more recently discovered materials vary from the material discovered by Onnes. **1**

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Physics

Trial Examination **Solutions**

HSC Course

2007

General Instructions

Reading time - *5 minutes*

Working time - *2 hours 15 minutes*

Board-approved calculators may be used.

Write using blue or black pen.

Draw diagrams using pencil.

Formulae sheets and a Periodic Table are provided with this question paper.

Answer all questions in the spaces provided.

Total Marks (75)

This paper has one section with two parts:

Section I

Total marks (75)

Part A

15 marks – attempt questions 1 - 15

Part B

60 marks – attempt questions 16 - 30

Section I

Total Marks (75)

Part A

Total Marks (15)

Attempt Questions 1 – 15

Allow about 30 minutes for this part

For each question place a cross (X) in the column which matches your choice.

Question	A	B	C	D
1			X	
2			X	
3		X		
4			X	
5			X	
6				X
7			X	
8	X			
9				X
10		X		
11		X		
12	X			
13				X
14	X			
15		X		

Question 5 has no correct answer as it is stated. Choice C is the best alternative of those available.

Section I continued

Part B

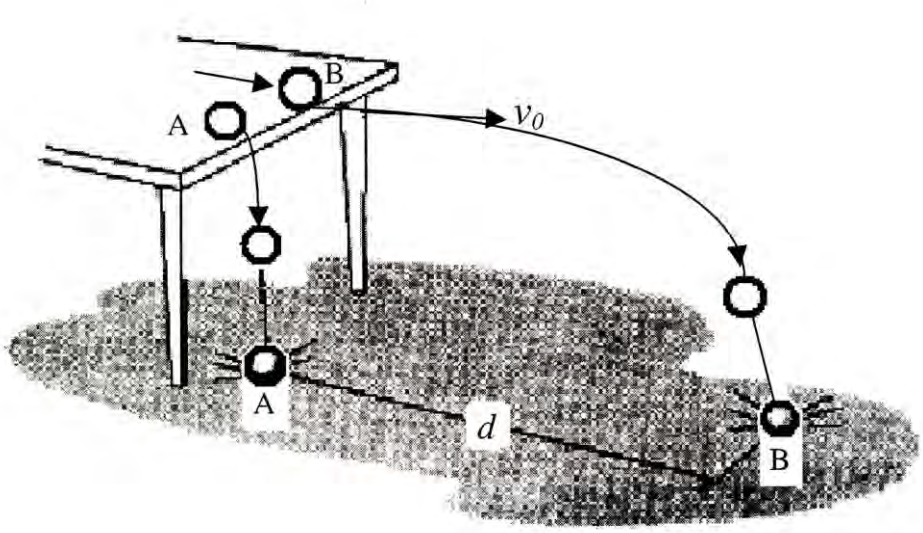
Total Marks (60)

Attempt Questions 16 – 30

Allow about 1 hour and 45 minutes for this part

Question 16 (4 marks)

Two students studying projectile motion are comparing the motion of two balls, A and B. They drop ball A from the edge of the bench, 0.90 m high, while rolling an identical ball B along the bench. The balls leave the bench at the same instant, A with zero horizontal velocity while B has a horizontal velocity of 6 ms^{-1}.

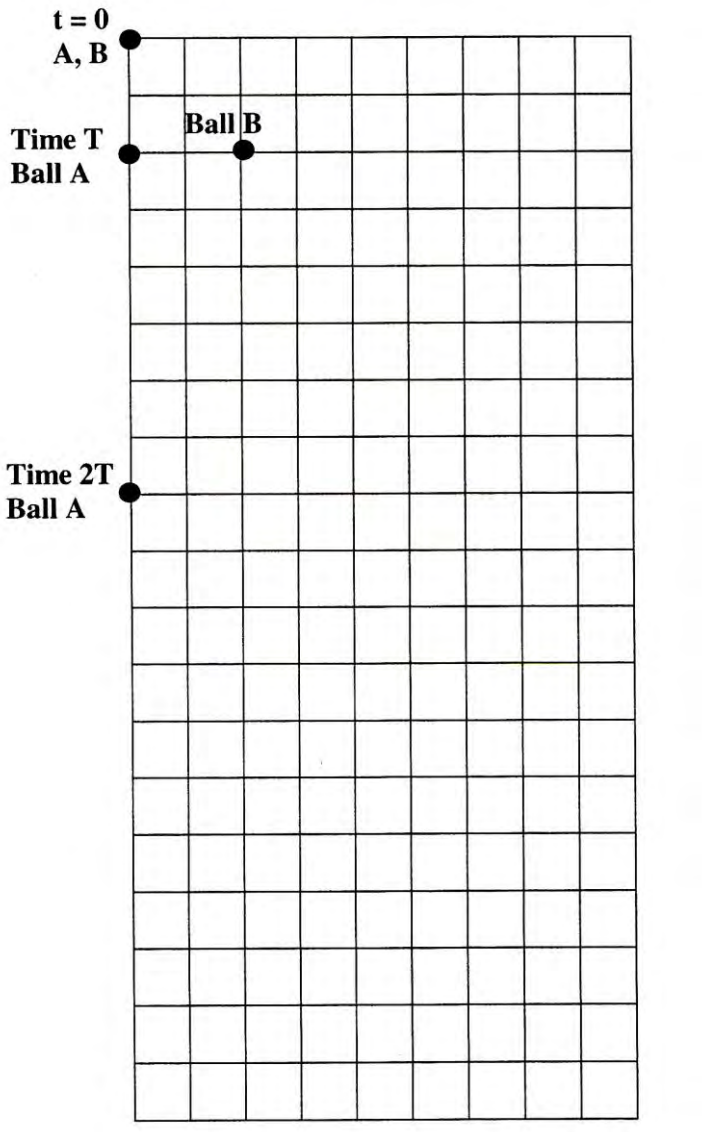


(a) *Determine the extra distance, d, that ball B lands from the edge of the bench, compared to ball A.* **2**

Calculate time taken for ball to reach floor; same as if dropped vertically; use $t = \sqrt{2s/a}$ *gives* $t = 0.43s$

Then range is given by distance = speed x time = 6 x 0.43 = 2.6 m

The students use a flashing light and a long camera exposure to photograph the falling balls. The students use the photo to draw a plot of the trajectory of the two balls. The flash rate is not known so the students label the time interval between flashes T. On the graph below, the position of ball A at t = 0 and at time T and 2T have been drawn. The position of ball B at t= 0 and at time T has been drawn.



(b) On the graph above, draw the position of ball B at time 2T. **1**

At time T, ball B is level with ball A but has moved 2 more units across.

(c) On the graph above, draw the position of ball A at time 3T. **1**

At time 3T, ball A is 18 units below its position at t = 0.

Question 17 (3 marks)

(a) Explain the concept of g-force. **2**

The g-force scale is a relative scale. Measurement of the force acting on an object is expressed in multiples of the object's weight at sea level.

(b) Identify ONE strategy used during rocket take off to minimise the effect of the g-force acting on astronauts. **1**

Astronauts lie horizontally (i.e. perpendicular to velocity) facing upwards.

Question 18 (3 marks)

A satellite has a mass of 250 kg and orbits the Earth at an altitude of 3000 km. The Earth's equatorial diameter is 12 756 km.

(a) Determine its orbital speed. **2**

$v = \sqrt{(GM_e/r_e)} = \sqrt{(6.67 \times 10^{-11} \times 6.0 \times 10^{24} / 6.37 \times 10^{6})} = 6.5 \times 10^{3}\ ms^{-1}$

(b) Compare the orbital speed of a 500 kg satellite with the speed of the 250 kg satellite in an identical orbit. **1**

The orbital speed is the same, as orbital speed is independent of the mass of the satellite.

Question 19 (3 marks)

Explain the idea of the relativity of simultaneity, giving an example to support your answer. **3**

The principle of simultaneity states that two events which appear to be simultaneous in one frame of reference may not appear to be simultaneous in a different frame of reference. For example, two exploding stars may be observed to appear in the night sky at the same instant of time by an astronomer on Earth, but an observer in a different part of the galaxy may notice that the star furthest from Earth actually exploded many thousands of years before the star closest to earth.

Question 20 (4 marks)

(a) Why did early scientists propose the need for the existence of the aether? **1**

Experiments had shown that light was a wave and all other known waves (at the time) required a medium for transmission so they assumed that light too would require a medium. So space had to be "filled" with a substance called the aether.

(b) It is recognised that the Michelson-Morley experiment will always have a null result, whether or not the aether exists.

Explain this statement. **2**

It is now known that the speed of light is absolute i.e. it is independent of the motion of the observer. So any variation between the time taken for light to travel into or across an aether will be non-existent. This means that variations in an interference pattern produced by the arrival of light waves after travelling the same distance along different paths will also be non-existent. Hence a null result will always be produced.

Question 21 (3 marks)

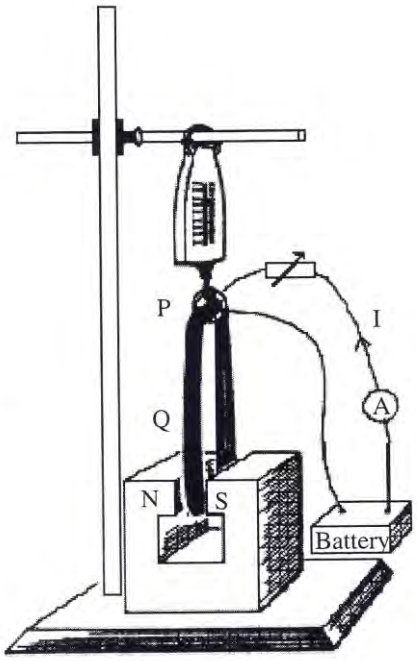
Discuss the implications of time dilation and mass increase for space travel. **3**

Time dilation effects mean that space travel at relativistic speeds would be more viable than at slower speeds we are capable of at present because long journeys could conceivably be made within a reasonable time as far as the astronaut(s) are concerned. This has positive implications for food, water and air resources and for the psychological well being of the crew.

However, the fuel needed to accelerate the spacecraft to near light speeds, particularly given the mass increase that accompanies this means that it is improbable, with current technology, o attain those speeds.

Question 22 (5 marks)

Asked to consider a model electric meter, a group of students used a spring balance and a coil of wire suspended between the poles of a horseshoe magnet as shown below. The coil had 100 turns, weighed 1.6 N and was 20 cm high and 5 cm wide. The poles of the magnet were wider than the coil and the spring balance had a scale of 0 to 5 newtons. A variable resistor and an ammeter were included in the circuit for calibration purposes.



(a) When the switch was closed, the spring balance reading increased from 1.6 N to 1.9 N when a current of 0.20 A flowed through the circuit. Calculate the magnetic field strength between the poles of the magnet. **1**

Use $F = nBIl$; re-arrange for B gives $B = F / nIl = 0.3$ T

(b) In what direction was the current flow along section PQ of the coil? **1**

From P to Q

(c) Calculate the largest current that could be measured using the spring balance. **1**

2.3 A

Question 22 is continued on the next page

Question 22 Continued

(d) The students stated that they could calculate the current by substituting the spring balance reading into a simple formula, provided they adjusted the position of the coil.
Justify this statement. **2**

When the current through the coil is altered, the force on the coil will vary and cause the coil to hang in a different position between the magnetic poles and not be subjected to the same magnetic field. By ensuring that the coil experiences the same magnetic field, I = (Force reading - 0.16) / 1.5

Question 23 (5 marks)

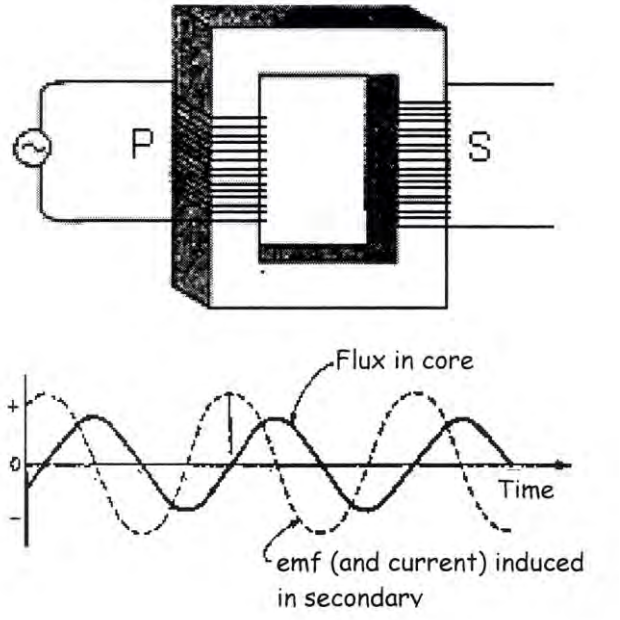
In the 1880s Westinghouse and Edison competed to supply electricity to cities in America until finally it was decided that alternating current provided the most efficient electricity supply.

Discuss reasons for the efficiency of alternating current in BOTH its production and transmission when compared to direct current. **5**

DC systems have considerable energy losses in transmission and generating systems are more complex and expensive. DC transmission is limited to shorter distances than AC. Energy losses in transmission lines are determined by the power formula $P\ I^2R$ where I is the current flowing and R is the total resistance. This indicates that energy loss increases with distance and greatly increases with current. Therefore it is best to transmit at low(er) current and high(er) voltage so that the needed power level is still available to the user. (Power transmitted = VI) This is easily accomplished in AC systems using transformers.

Question 24 (4 marks)

The transformer below has 14 turns in the primary coil and 28 turns in the secondary coil. The graph shows how the flux in the iron core of the transformer is related to the emf and current induced in the secondary coil.



(a) If the voltage across the secondary coil is 60 volts, calculate the input voltage. **1**

V_p / 60 = 14 / 28 Therefore V_p = 30 V

(b) The graph shows that the emf across the secondary coil is a maximum when the flux through the iron core is zero. Explain this relationship. **1**

The emf generated is proportional to the rate of change of flux. So when the flux is changing most rapidly, the emf is a maximum. When there is no change in flux, the induced emf is zero.

(c) Explain how the heating problems of transformer cores are overcome. **2**

The heating effects of eddy currents are reduced by: the use of a laminated core, made up of thin sheets which are insulated from one another by non-conducting materials; the use of cores made of ferrites, complex oxides of iron and other metals that are ferromagnetic but have much greater resistance than iron and so reduce the size of the eddy currents.

Question 25 (6 marks)

Induction has many applications, being used in a number of electrical devices.

(a) Describe how an aluminium disc and a bar magnet can be used in an investigation performed in a school laboratory to demonstrate the principle of an AC induction motor. **3**

Many possible answers e.g. rotating a magnet close to a copper or aluminium disc which is free to rotate about an axis. The disc will begin to rotate in the same direction as the magnet, chasing the magnet in effect.

(b) Manufacturers state that induction cook tops can only be used with saucepans made from iron and purchasers are advised to use a refrigerator magnet to test their saucepans.
Since currents can be induced in metals other than iron, discuss the reasons for designing induction cook tops that require iron based saucepans. **3**

The coils in the cooking plate produce high frequency alternating magnetic fields set up by the alternating currents. The magnetic fields produce eddy currents in the cookware and this causes heating. This effect occurs in copper cookware but, due to copper's low resistance, the heating effect is minimal. Hence iron saucepans are recommended.

Question 26 (4 marks)

Explain the need for BOTH a high voltage and a lower voltage in different parts of a cathode ray oscilloscope. **4**

The high voltage is supplied to the electron gun where electron are produced by thermionic emission and are accelerated towards a screen. The electron beam is deflected horizontally and vertically using the electric field between parallel plates and these do not require such a high voltage.

Question 27 (2 marks)

State the advantages of the maglev train and explain the impact of superconductors on the development of this mode of transportation. **2**

A maglev train moves along a guideway that uses electromagnets to produce magnetic fields for suspension and other coils for guidance and propulsion. Because the normal friction with the rails is eliminated, very large speeds can be achieved by trains of streamlined design.
Since powerful magnetic fields in both the vehicle and the guideways are required, superconducting electromagnets are used. They are more energy efficient but achieving the low temperatures needed is difficult. As researchers discover materials that become superconductors at ever higher temperatures, the economics of building maglev trains will result in their increased use.

Question 28 (5 marks)

In the 1860s, Maxwell developed is famous equations describing the interaction of magnetic and electric fields resulting in the production of self-propagating "electromagnetic" waves.

(a) Outline the experiment performed by Hertz producing radio waves. **2**
(You may use a labelled diagram.)

Hertz set up a high alternating voltage between a small spark gap to produce a fast changing electric field, causing a spark to cross the gap. He reasoned that the changing electric field would set up a changing magnetic field and produce electromagnetic waves as predicted by Maxwell's theory. The receiver was a small metal loop with a gap and he noticed sparks in this loop whenever the spark oscillated across the high voltage gap.

(b) Explain how Hertz confirmed that his waves were the electromagnetic waves predicted by Maxwell's equations and that they had the same properties as light. **3**
Hertz used interference between the wave moving directly to the receiver and part of the same wave reflected by a metal plate to measure the wavelength. The frequency of the wave was the frequency of the alternating high voltage source. He used $v = n\lambda$. He found that the speed was as predicted by Maxwell and matched the known speed of light. His experiments also related radio waves to light waves by showing they had the same properties such as reflection, refraction, diffraction and polarisation.

Question 28 continues on the next page

Question 28 (Continued)

(c) Evaluate the importance of the experiments performed by Hertz to scientific theory and society. **2**

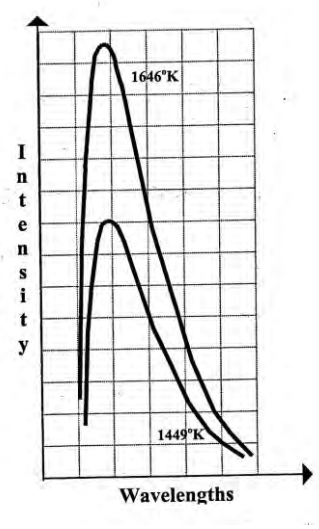
These experiments were evidence for the electromagnetic waves described by Maxwell's equations and for the electromagnetic nature of light waves. This resulted in the prediction of e/m waves of different frequencies. The waves produced by Hertz became known as radio waves and his method became the basis of producing waves of precise frequencies.
Electromagnetic waves of varying frequencies are the basis for modern communication technology and therefore his work was very important.

Question 29 (3 marks)

(a) What is meant by a "black body"? **1**

A black body absorbs all of the energy incident upon it and then re-radiates it.

(b) The diagram below shows the shape of the curve for the intensity of thermal radiation from a black body plotted against the distribution of wavelengths at two different temperatures.

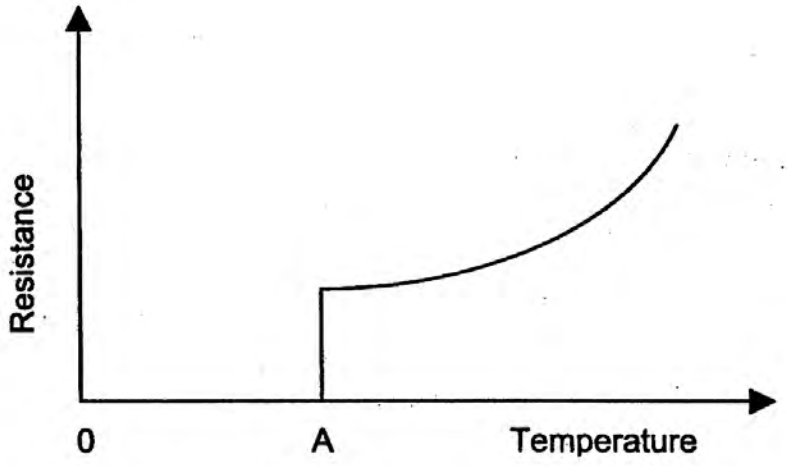


State the contribution that Planck made in his efforts to find a general formula for these curves. **2**

Planck offered the explanation that the shape could only be explained by thinking of radiation as a series of quanta or energy packets. Not all values of energy were possible. Only discrete amounts of energy , known as quanta, were possible.

Question 30 (4 marks)

(a) Give the name for the temperature marked as "A" on the graph below, and explain its physical significance. **2**



A represents the critical, or transitional, temperature. At this temperature the resistance of the material drops to zero and the material becomes superconducting.

(b) Onnes was the first scientist to discover this behaviour.
Name the metal he used and state the temperature at which the phenomenon occurred. **1**

Onnes used mercury. Its critical temperature is approx. 4K.

(c) Since the time of Onnes discovery (1911) other materials have been discovered which also demonstrate this type of behaviour.
Outline how these more recently discovered materials vary from the material discovered by Onnes. **1**

The type II superconductors are ceramics rather than pure metals. Their transition temperatures are much higher than those of type I conductors (the pure metals).