Fort Street High School

FORT STREET HIGH SCHOOL

Trial Higher School Certificate 2005

Physics

General Instructions

- Working time – 3 hours
- Reading time - 5 minutes
- Board approved calculators may be used
- Write in blue or black pen
- Draw diagrams in pencil
- Write all answers on the Answer sheets provided
- A Formula sheet, a Data Sheet and Periodic Table are provided .

- Write your name in the space below

Name :
Teacher : Fluitsma / Riley / Leondios

Section I
(75 marks)

Part A - 15 marks

- Attempt questions 1 – 15
- Allow about 30 minutes for this part

Part B – 60 marks

- Attempt questions 16 – 30
- Allow about 1 hour 45 minutes for this part

Section II
(25 marks)

- Attempt all parts of the Option question
- Allow about 45 minutes for this part

Total marks for this task **(100)**

1 Of the following, which is the most suitable orbit for a communications satellite?

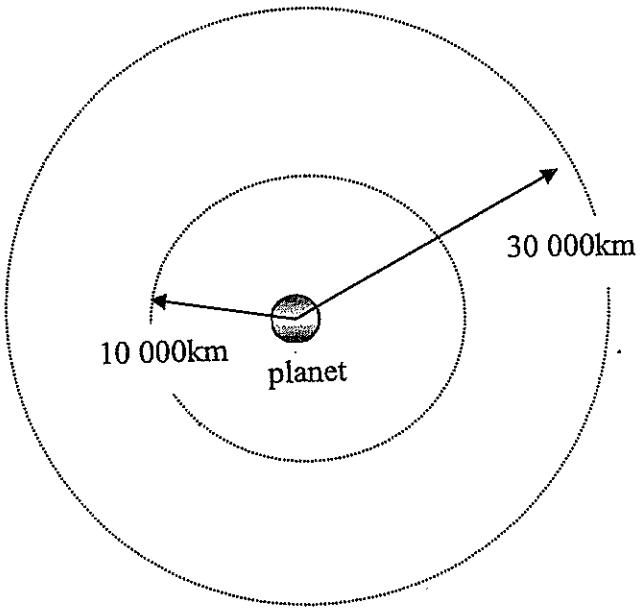
(A) geosynchronous

(B) geostationary

(C) polar

(D) low Earth

2 A satellite with an orbital radius of 10 000km around a newly discovered planet has a period of 5 hours. Another satellite enters a stable orbit with a 30 000km radius around the same planet. The second satellite's period would be closest to:



(A) 1 hour

(B) 15 hours

(C) 26 hours

(D) 135 hours

3 The Michelson-Morley experiment showed that:

(A) the aether did not exist.

(B) the aether did not affect light.

(C) light travels at the same speed regardless of direction.

(D) light could travel through a vacuum.

4 Which statement about the acceleration of a rocket lifting with constant thrust is correct?

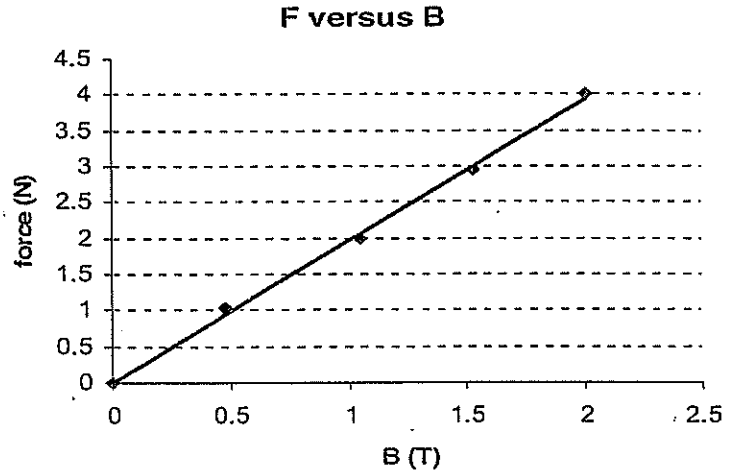
(A) It increases as its mass decreases

(B) It increases with altitude as the Earth's gravitational force decreases

(C) It remains constant as the thrust is constant

(D) It decreases as fuel is used up

5 A straight length of wire is connected so that a constant 5.0A current flows. The wire is placed in a magnetic field which is perpendicular to the current. The force on the wire is measured as the magnetic field strength is varied. The results are shown below:



The length of the wire within the magnetic field is:

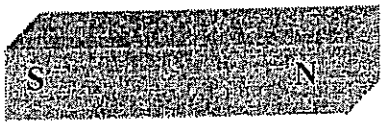
(A) 1.0cm

(B) 10cm

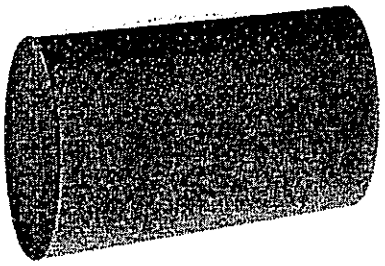
(C) 40cm

(D) 100cm

6 A solenoid is held close to the end of a bar magnet, as shown:



bar magnet



solenoid

The greatest current in the solenoid would be briefly produced by:

(A) moving the magnet slowly through the solenoid.

(B) moving the solenoid quickly towards the magnet.

(C) moving the solenoid slowly over the magnet

(D) moving the solenoid only slowly to the right away from the magnet.

7 A step up transformer has a coil ratio of 1:6. The input voltage is 240V. Input current is 15A. What is the output voltage and current?

(A) 40V, 2.5A

(B) 40V, 90A

(C) 1440V, 2.5A

(D) 1440V, 90A

8 A cathode ray tube with a rotating paddle wheel which turns when the cathode rays strike the paddles is evidence that cathode rays possess:

(A) charge but no mass.

(B) mass but no charge.

(C) mass.

(D) charge.

9 What was Planck's hypothesis about the photoelectric effect?

(A) black body radiation is quantized

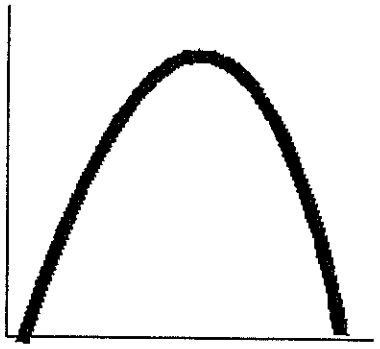
(B) radio waves are polarized

(C) black body radiation is independent of the material used

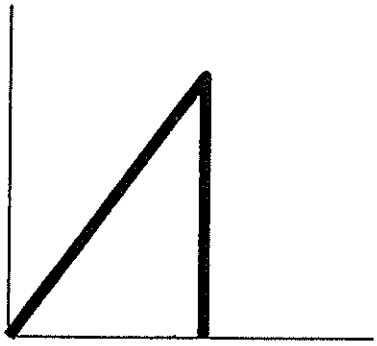
(D) vibrating electrons can act as radio antennae

10 Galileo's contribution to projectile motion predicted that the shape of a projectile's path would most closely resemble:

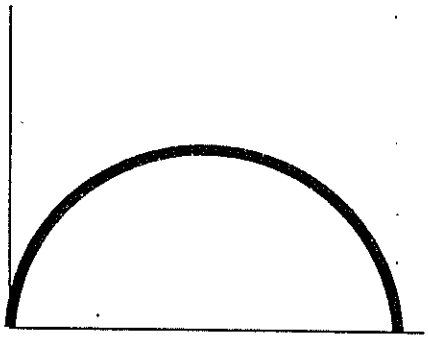
(A)



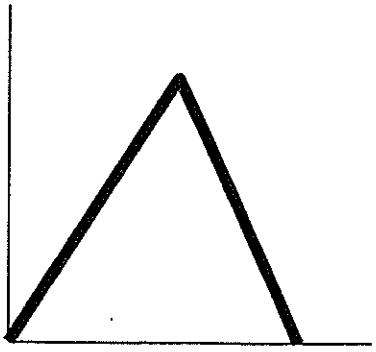
(B)



(C)



(D)



11 The torque on a current-carrying loop of wire with current I, within a magnetic field with intensity B with an area A would double when:

(A) The magnetic field intensity is increased to 2B and the current increases to 2I.

(B) The magnetic field intensity is increased to 2B and the current is halved to I/2.

(C) The current is increased to 2I.

(D) The current is increased to 2I and the area is halved to A/2.

12 In an experiment to demonstrate the photoelectric effect, it was found that when light with a frequency f and an intensity I was shone on the cathode, the voltage needed to completely stop the photoelectric current was V volts.

The effect of reducing the intensity of the light shining on the cathode is that the voltage V:

(A) became zero.

(B) increased.

(C) decreased.

(D) remained the same.

13 When some substances are cooled to very low temperatures, their electrical resistance drops to zero. What is this called?

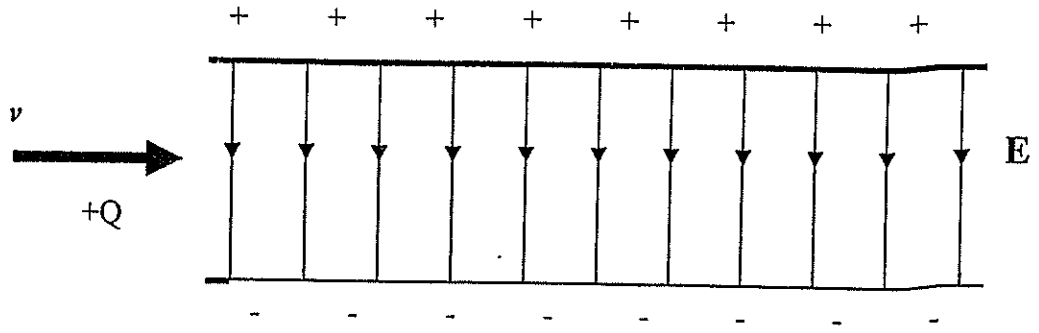
(A) the photoelectric effect

(B) black body radiation

(C) thermionic emission

(D) superconductivity

14 A charged particle +Q enters a region of electric field E between two parallel plates, as shown. The particle's speed before entering is v.



The apparatus is in a vacuum and the experiment is being performed in weightless conditions.

Which statement best describes the motion of the charged particle +Q upon entering the electric field E?

(A) +Q will move in a circle to the left of its original direction.

(B) +Q will slow down.

(C) +Q's direction will change to the right of its original path, down the page.

(D) +Q's direction will change to the left of its original path, into the page.

15 The Braggs' experiment:

(A) used diffraction patterns of light to develop the model of metallic bonding

(B) used diffraction patterns of X-rays to determine crystal structure

(C) used a goniometer to bombard a crystal structure with X-rays

(D) used large sized crystal samples to determine its structure using diffraction

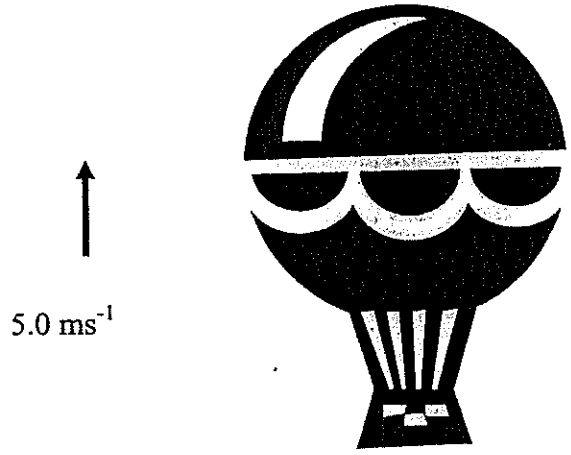
Part B – 60 marks
Attempt Questions 16-30
Allow about 1 hour and 45 minutes for this part.

Answer the questions in the spaces provided.
Show all relevant working in questions involving calculations.

Marks

Question 16 (4 marks)

A hot air balloon is rising vertically at $5.0ms^{-1}$. A passenger drops a stone from the balloon and times how long the stone takes to hit the ground below.



The stone takes 3.90s to hit the ground.

(a) Calculate the height of the balloon when the stone was dropped. **3**

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Question 16 (continued)

Marks

(b) If the balloon had been moving to the north at $2.0ms^{-1}$ as the stone was dropped, what horizontal distance would the stone move while it is falling? **1**

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Question 17 (5 marks)

Many rocket launching facilities are located close to the equator. When placing satellites into Earth orbit, the rockets are almost always launched towards the east.

(a) Discuss the reasons for the information in the above statement with particular reference to Earth-orbiting satellites. **3**

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(b) Satellites in low earth orbit, such as the International Space Station, require regular firing of booster rockets to maintain their altitude. **2**

Account for this requirement.

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Marks

Question 18 (3 marks)

The Space Shuttle orbits the Earth, but cannot reach the outer planets of our solar system. Account for this fact in terms of the orbital velocity of the Space Shuttle and Earth's escape velocity. 3

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Question 19 (3 marks) **Marks**

The acceleration due to gravity varies around the earth's surface.

a) State two reasons as to why the acceleration due to gravity on the surface on the earth is not a constant value. 2

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b) When in circular orbit with an altitude of 250 000 metres, a spaceshuttle has a mass of 80 000 kg. If the shuttle is traveling at 7800 ms^{-1}, what is the centripetal force acting on the shuttle? 1

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Question 20 (4 marks) **Marks**

Describe the main structures present in an AC generator, which are absent in a DC generator and how these structures function to output the different type of currents produced by the generators. 4

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Question 21 (5 marks)

"Lenz's Law does not contradict the Law of Conservation of Energy".

(a) Discuss this statement using the example of the production of back emf in a motor. 3

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Marks

(b) Explain how induction cooktops use the same principle as that which produces back emf in motors. 2

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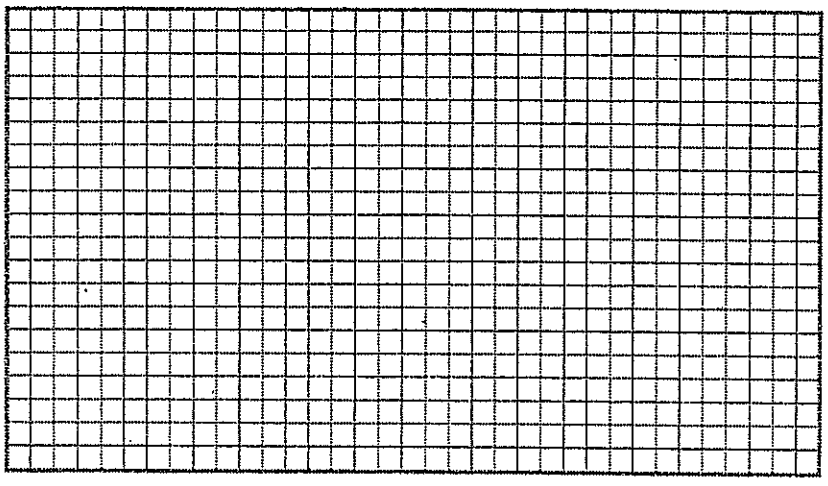
Question 22 (5 marks)

In an experiment to determine the relationship between the energy of photons and their frequency the results shown in the table below were obtained.

E (x 10^{-19} J)	1.65	2.69	3.88	4.05	4.48	5.54
f (x 10^{14} Hz)	2.5	4.2	5.7	6.1	7.0	8.2

a) Plot the data and draw a line of best fit on the axes provided. 2



(b) From the graph, calculate the gradient of the line of best fit. 1

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Question 22 (continued) **Marks**

(c) Write an expression showing that the energy, E of a photon is proportional to its frequency, f. **1**

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(d) List an advantage of using graphical techniques such as those used above to find the value of a constant **1**

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Question 23 (4 marks)

"*My part in producing the atomic bomb consisted in a single act: I signed a letter to President Roosevelt, pressing the need for experiments on a larger scale in order to explore the possibilities for the production of an atomic bomb.*
I was fully aware of the terrible danger to mankind in case this attempt succeeded. But the likelihood that the Germans were working on the same problem with a chance of succeeding forced me to this step. I could do nothing else although I have always been a convinced pacifist. To my mind, to kill in war is not a whit better than to commit ordinary murder". (**Albert Einstein**, 1952)

It is well recorded in history that Planck and Einstein's views on the role of Science in Politics and Society differed. Using the above quote from Einstein, discuss how Einstein's views differed from Planck's. **4**

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Marks

Question 24 (4 marks)

The shortcomings in communication technology are widely regarded as contributing to the development of the transistor, together with an increased knowledge of the properties of certain materials.

(a) The increased knowledge of which type of materials was necessary in order for the transistor to be invented? **1**

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(b) Discuss how the shortcomings in communication technology eventually lead to the invention of the transistor. **3**

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Question 25 (4 marks)

Describe the impact of the development of transformers on society. **4**

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Marks

Question 26 (5 marks)

An electron in the solar wind enters the Earth's magnetosphere with a speed of $300 kms^{-1}$. The region of the magnetosphere has a magnetic field intensity of $7.5 \times 10^{-5} T$, and is directed perpendicularly to the velocity of the electron.

(a) Calculate the magnitude of the force on the electron as it enters the magnetosphere. **2**

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(b) Explain how the same force, observed when cathode rays enter a magnetic field, is evidence that cathode rays carry a large electric charge with little mass. **3**

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Question 27 (4 marks)

Marks

Hertz was able to devise a way of measuring the speed of radio waves which did not rely on timing how long they took to travel a given distance.

Construct a diagram of Hertz's experiment and briefly outline the procedure he used. 4

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Marks

Question 28 (5 marks)

Alternating current is produced on a very large scale for mains electric power supplies. On a much smaller scale, you performed an investigation in the laboratory to demonstrate the production of an alternating current.

(a) Sketch the apparatus you used and state how the alternating current was produced and detected. **3**

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(b) Electrical energy provided to homes is in itself not very useful. Identify THREE (3) *different* forms of energy that electricity is converted to in the home, stating the name of ONE device used for each of the three conversions. **2**

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Marks

Question 29 (3 marks)

The Michelson-Morley experiment did not show any difference in the speed of light when light rays travelled in directions perpendicular to each other.

Evaluate the results of this experiment in terms of its original purpose, i.e. to show the existence of the aether wind due to Earth's motion. 3

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Question 30 (2marks)

Describe the concept of doping a semiconductor with various elements from the periodic table to form n-type and p-type semiconductors. Use a diagram in your answer. 2

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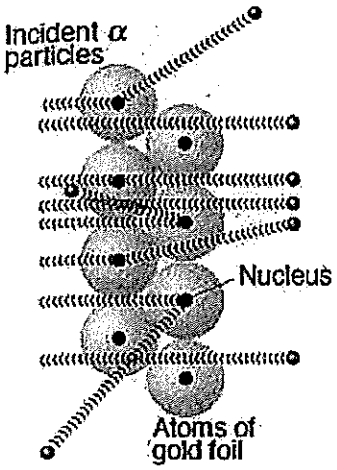
Name: .....

Quanta To Quarks (25 marks)

Question One (5 marks)

Marks



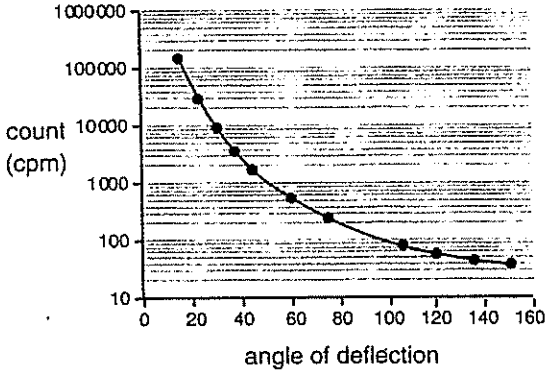
Rutherford conducted an experiment to determine the structure of the atom.
This experiment involved bombarding a thin piece of gold foil with alpha particles (positively charged).The results are shown in the diagram to the left.
He observed that most of the particles passed through the gold foil and a very small number were scattered from their original path.

Keeping in mind **charges** and **features** of atoms, propose a suitable explanation for each of the two observations using the table below as a scaffold.

Observations	**Explanation**
Scattering (deflection) of alpha particles	
Alpha particles continuing through gold foil in a straight line	

2

The graph below shows the relationship between angle of deflection and number of counts recorded during a Rutherford scattering experiment using a thin gold foil.



a) Estimate the number of counts at 25° deflection **1**

b) Contrast the deflections at small and large angles **1**

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Question Two (9 marks) **Marks**

The Hydrogen spectrum is a set of wavelengths emitted when electrons in atoms move from one energy level to another. Balmer's equation can be used to calculate the wavelength (in nm) of various lines in the Hydrogen spectrum. This equation is:

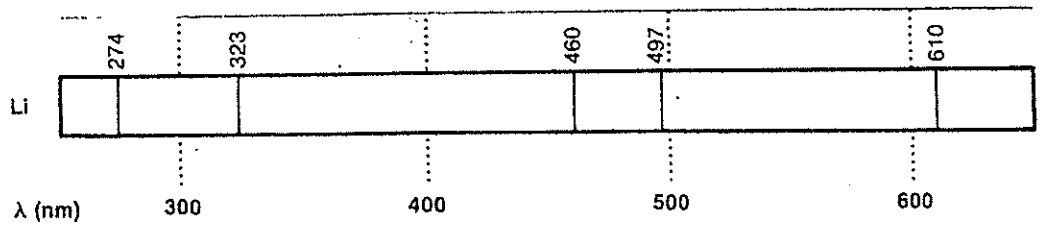
$$\lambda = b\left(\frac{n^2}{n^2 - 2}\right)$$

where λ = wavelength (nm)
$b = 364.5$
$n = 3, 4, 5, 6 \ldots\ldots$ (an integer)

Use Balmer's equation to calculate the wavelengths required in the following table **2**

Spectral Line	n	λ(nm)
H_α	3	
H_β	4	
H_γ	5	
H_δ	6	
H_ε	7	
H_ξ	8	
H_η	9	
H_θ	10	

A spectral diagram represents wavelengths emitted by atoms. The spectral diagram for Lithium is shown below.



Read next page for question regarding spectral diagram.....

eate a spectral diagram for Hydrogen using the values you have calculated in the able above by

i) constructing a labelled horizontal axis to include wavelengths calculated above and then..

ii) drawing a vertical line approximately 2cm long in suitable positions on the axis to represent each spectral line.

3

The following table shows approximate wavelengths for colours in the visible spectrum.

Colour	**λ range (nm)**
Violet	400-440
Blue	440-490
Green	490-560
Yellow	560-590
Orange	590-630
Red	630-700

Construct a table that

i) demonstrates which of the wavelengths of Hydrogen spectra will be visible to the human eye and

ii) identifies the colour that each will appear.

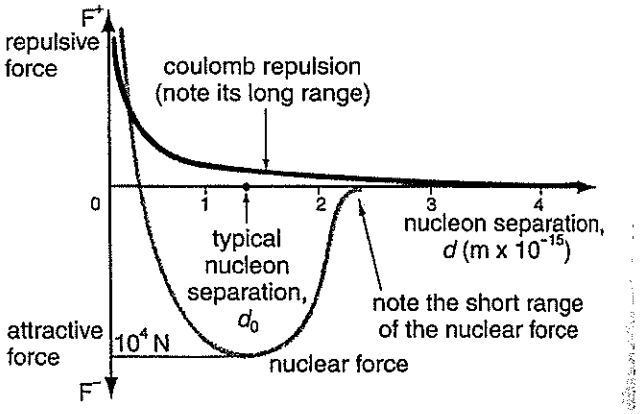
4

Question Three (2 marks) **Marks**

A nucleus is made of positively charged protons and neutral neutrons. A proton near another proton will repel so, if a nucleus is to stay together and not burst apart due to electrostatic repulsions, there must be another force. This force is called the strong nuclear force. It:

- holds all nuclear particles together, whether charged or uncharged
- is much stronger than electrostatic forces
- is attractive over only a very small distance (about 10^{-15}m)
- becomes repulsive at small distances (less than 0.5×10^{-15}m)

This is summarised in the graph below.



Predict whether the nuclear force will be attractive or repulsive if two nucleons are: **2**

a) between 1×10^{-15}m and 2.3×10^{-15}m
b) less than 0.5×10^{-15}m apart

Question Four (4 marks)

Calculate the F_G and F_E of two protons in a nucleus using the formula shown, given that the distance between two protons in a nucleus is 1.0×10^{-15}m.

$$F_G = \frac{Gm_1m_2}{r^2} \quad \text{and} \quad F_E = \frac{Kq_1q_2}{r^2}$$

where $G = 6.673 \times 10^{-11}$
$K = 9 \times 10^9$
m = mass proton = 1.673×10^{-27} kg
q = charge on proton = 1.6×10^{-19} C
r = distance between protons in a nucleus :

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Calculate the ratio $F_E : F_G$

1

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Compare a cyclotron and a synchrotron **4**

Similarities
Differences