2001 HIGHER SCHOOL CERTIFICATE EXAMINATION

Physics

Centre Number

Student Number

Section I (continued)

Part B – 60 marks
Attempt Questions 16–26
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)

Muons are very short-lived particles that are created when energetic protons collide with each other. A beam of muons can be produced by very-high-energy particle accelerators.

The high-speed muons produced for an experiment by the Fermilab accelerator are measured to have a lifetime of 5.0 microseconds. When these muons are brought to rest, their lifetime is measured to be 2.2 microseconds.

(a) Name the effect demonstrated by these observations of the lifetimes of the muons. **1**

time dilation.

(b) Calculate the velocity of the muons as they leave the accelerator. **3**

$t_v = \dfrac{t_0}{\sqrt{1-v^2/c^2}}$ $\quad t_v = 5.0\,\mu s = 5.0\times10^{-6}\,s.$

$t_0 = 2.2\,\mu s = 2.2\times10^{-6}\,s.$

$5.0\times10^{-6}\,s = \dfrac{2.2\times10^{-6}\,s}{\sqrt{1-v^2/3.00\times10^8\,m/s}}$

$\sqrt{1-v^2/3.00\times10^8} = \dfrac{2.2\times10^{-6}}{5.0\times10^{-6}}$

$1-\dfrac{v^2}{3.00\times10^8} = \left(\dfrac{2.2}{5.0}\right)^2 \qquad \dfrac{v^2}{3.00\times10^8} = 1-\left(\dfrac{2.2}{5.0}\right)^2$

$\therefore v = \sqrt{3.00\times10^8\left(1-\left(\frac{2.2}{5.0}\right)^2\right)}$

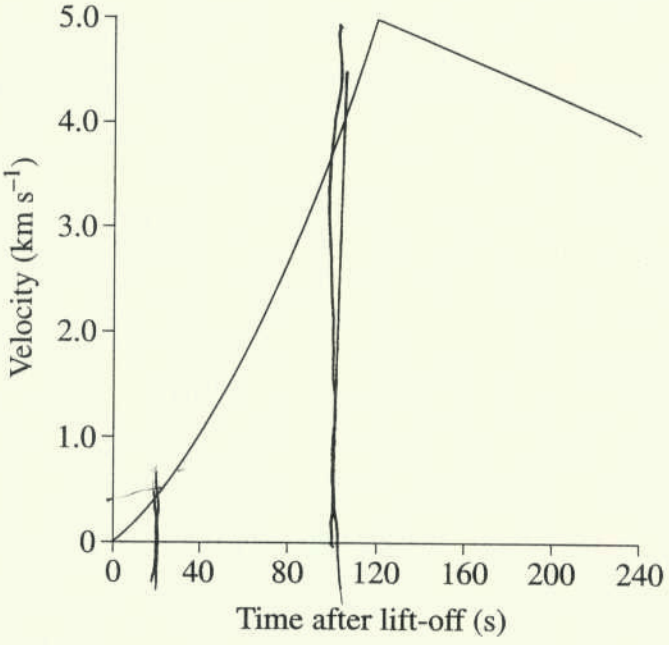
$= 15553.78\ m/s$

$= 1.6\times10^4\ m/s$

Marks

Question 17 (6 marks)

A rocket was launched vertically to probe the upper atmosphere. The vertical velocity of the rocket as a function of time is shown in the graph.



(a) Using either words or calculations, compare the acceleration of the rocket at $t = 20$ s with its acceleration at $t = 100$ s. **2**

acceleration at $t=20s = \frac{0.5}{20} = 0.025$ km s^{-2}
acceleration at $t=100s = \frac{4}{100} = 0.04$ km s^{-2}
∴ the acceleration at 100s is greater than the acceleration at $t=20s$

(b) Account for the shape of the graph over the range of time shown. **4**

During the first 120s the rocket is increasing in velocity, it is accelerating. ~~After the 120s mark the~~ This is because it is burning up fuel. Since $F=ma$ the less mass, the greater the acceleration. After the 120s mark the velocity decreases proportional to time this could mean that the rocket's engine might be turned off or it has stopped burning fuel and is allowing the rock to go on its momentum gained from the initial acceleration. It's velocity then gradually slows down.