2001 HIGHER SCHOOL CERTIFICATE EXAMINATION

Physics

Centre Number

Section I (continued)

Student Number

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 dialation

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

$t_v = t_0 / \sqrt{1 - \frac{v^2}{c^2}}$ 1 Microsecond = $\frac{1}{1000}$

$5 = 100 / \sqrt{1 - v^2/(3\times10^8)^2}$

$(\frac{1}{5})^2 = 1 - v^2/9\times10^{16}$

$v^2 = (1 - \frac{1}{25}) \times 9\times10^{16}$

$v = 864\,0000 \approx 8.64\times10^6$

$v = 2.9994\times10^9$

$5 = 1/\sqrt{1 - v^2/(3\times10^8)^2}$

$(\frac{1}{5})^2 = 1 - v^2/9\times10^{16}$

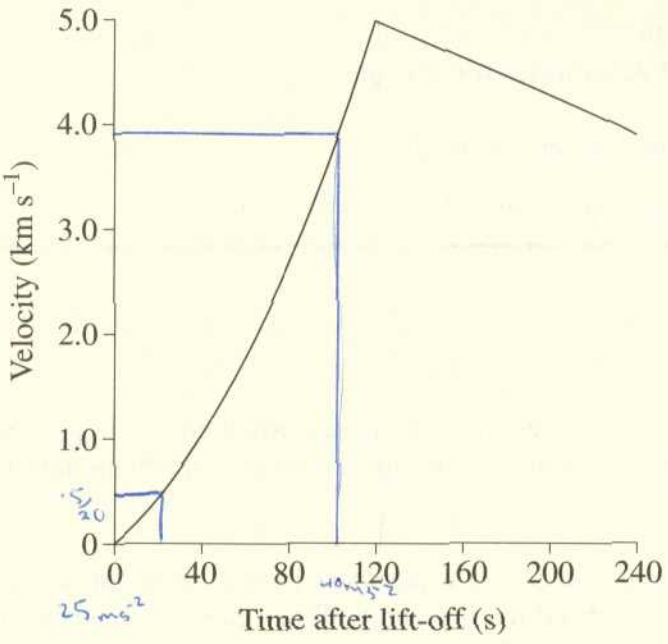
$v^2 = (1 - \frac{1}{25}) \times 9\times10^{16}$

$v = 2.939\times10^8$ 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**

The acceleration at t=100s is greater than that at t=20s because at t=100, $a = \frac{4000 ms^{-1}}{100s} = 40 ms^{-2}$ whereas at t=20, $a = \frac{500}{20} = 25 ms^{-2}$. This is shown because the gradient of the graph is greater at t=100s than t=20s.

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

At t=0 the rocket is at rest. The concave up shape of the graph between t=0s and t=120s suggests that the acceleration of the rocket is increasing over the time range to t=120s. However at t=120s the rocket begins to undergo negative constant acceleration until t=240s. This may be due to the fact that fuel has run out and no more thrust is produced.