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**

$t_v = 5.45$

$t_0 = 2.2\,\mu s$

$c = 3 \times 10^8\ ms^{-1}$

$5 = \dfrac{2.2}{\sqrt{1 - \frac{v^2}{c^2}}}$

$\dfrac{2.2^2}{5^2} = 1 - \dfrac{v^2}{c^2}$

$\dfrac{v^2}{c^2} = 1 - \dfrac{2.2^2}{5^2}$

$v^2 = c^2\left(1 - \dfrac{2.2^2}{5^2}\right)$

~~$v^2 = 24192000$~~

~~$v = 15553.78\,ms^{-1}$~~

$v^2 = c^2 \times 0.8064$

$v^2 = 7.2576 \times 10^{16}$

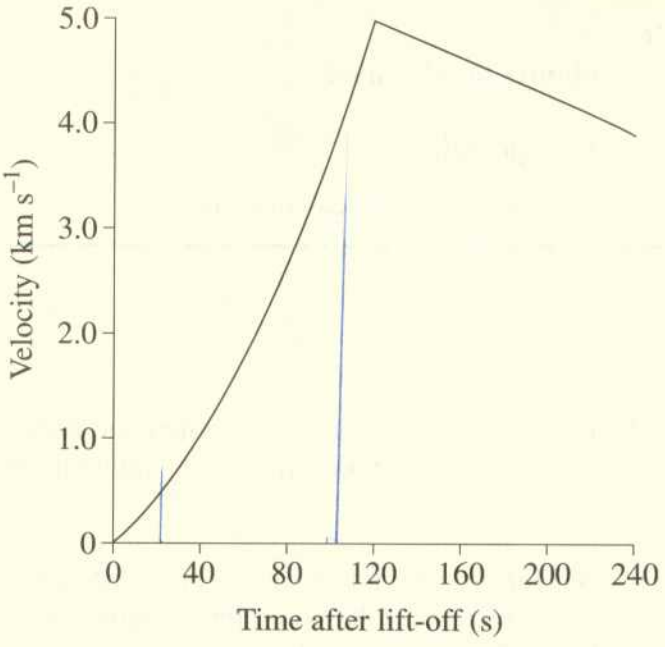
$v = 269399331.8\,ms^{-1}$

$= 2.69 \times 10^8\ ms^{-1}$

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=100 s is greater than that when t=20 as the velocity increases the greatest in the same time period at t=100 seconds. As time passes, fuel is being burnt and so mass decreases. As force is constant, then acceleration must increase as mass decreases (F=ma).

F=ma

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

As time passes, ~~mass~~ fuel is burnt, and so mass decreases. As force is constant, acceleration ~~is~~ increases and ~~so~~ so the velocity of the rocket increases. Initially, rocket has not started to burn fuel so no velocity. ~~increase~~. However, velocity increases ~~until~~ t=120, and then decreases as the engines are cut off and a stage is ejected. When this happens, there is no upward acceleration as no fuel is being burnt. There is downward acceleration due to gravity, and this is opposite in direction to the velocity ∴ the velocity decreases.

F=ma