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**

$t = \dfrac{t_0}{\sqrt{1-\frac{v^2}{c^2}}}$

$5\times10^{-6} = \dfrac{2.2\times10^{-6}}{\sqrt{1-\frac{v^2}{c^2}}}$

$\sqrt{1-\frac{v^2}{c^2}} = \dfrac{2.2\times10^{-6}}{5\times10^{-6}} = 0.44$

$1-\frac{v^2}{c^2} = 0.1936$

$\frac{v^2}{c^2} = 0.8064$

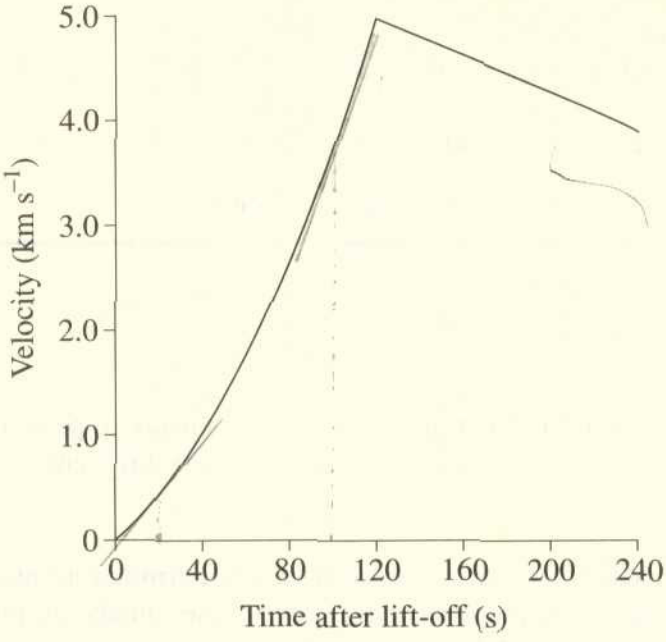
$v^2 = 0.8064 \times 3\times10^8 = 3\times10^8$

$v = 15554\ ms^{-1}$ (near whole number)

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 is the change in velocity over time. this is equivalent to the gradient of the curve (as this is $\frac{dv}{dt}$ or $\frac{\Delta v}{\Delta t}$) the gradient at $t=20$ is shallower (from observation of the graph) than at $t=100_s$, therefore acceleration is less at $t=20_s$

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

From $t=0$ to $t=120_s$, the graph is steadily increasing in a curve. this shows the velocity is increasing over these 120 seconds, hence it is accelerating and to $t=240$, acceleration is increasing from $t=120$ on, the curve decreases on a straight plane. this indicates that the rockets velocity is decreasing, hence it is decelerating at a constant (negative) acceleration as the line is straight.

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