Answer on Question #80325 - Physics - Mechanics – Relativity

1. A 745i BMW car can brake to a stop in a distance of 121 ft. from a speed of 60.0 mi/h. To brake to a stop from a speed of 80.0 mi/h requires a stopping distance of 211 ft. What is the average braking acceleration for (a). 60 mi/h to rest, (b). 80 mi/h to rest (c). 80 mi/h to 60 mi/h? Express the answers in mi/h/s and in m/s squared.

Solution

a) Calculate the average braking acceleration for 60 mi/h. 1 mile is 5280 feet, 1 feet is 0.3048 m:

$$a = \frac{\Delta v}{t}, \qquad s = \frac{at^2}{2} \Rightarrow a = \frac{\Delta v^2}{2s} = \frac{(0-60)^2}{2\cdot\frac{121}{5280}} \cdot \frac{1}{3600\ \mathrm{s}} = 21.82\ \frac{\mathrm{mi}}{\mathrm{h\cdot s}} \text{ or } 9.75\ \frac{\mathrm{m}}{\mathrm{s^2}}.$$

b) For 80 mi/h:

$$a = \frac{\Delta v^2}{2s} = \frac{(0-80)^2}{2\cdot\frac{211}{5280}} \cdot \frac{1}{3600\ \mathrm{s}} = 22.24\ \frac{\mathrm{mi}}{\mathrm{h\cdot s}} \text{ or } 9.94\ \frac{\mathrm{m}}{\mathrm{s^2}}.$$

c) Assume that the distance required to slow down from 80 mi/h to 60 mi/h is (211 – 121) ft = 90 ft:

$$a = \frac{\Delta v^2}{2s} = \frac{(60-80)^2}{2\cdot\frac{211-121}{5280}} \cdot \frac{1}{3600\ \mathrm{s}} = 3.26\ \frac{\mathrm{mi}}{\mathrm{h\cdot s}} \text{ or } 1.46\ \frac{\mathrm{m}}{\mathrm{s^2}}.$$

2. In a 100-m linear accelerator, an electron is accelerated to 1.00% of the speed of light in 40.0 before it coasts for 60.0 m to target. (a). What is the electron's acceleration during the first 40.0 m? (b). How long does the total flight take?

Solution

a) 1% of the speed of light is $0.01\cdot 3\cdot 10^8 = 3\cdot 10^6\ \mathrm{m/s}$.

$$a = \frac{\Delta v^2}{2s_1} = \frac{(3\cdot 10^6 - 0)^2}{2\cdot 40} = 1.125\cdot 10^{11}\ \frac{\mathrm{m}}{\mathrm{s^2}}.$$

b) Calculate the time:

$$t_1 = \frac{\Delta v}{a} = \frac{3\cdot 10^6 - 0}{1.125\cdot 10^{11}} = 2.67\cdot 10^{-5}\ \mathrm{s},$$

Speed at 60 m reached by acceleration a:

$$v_2 = \sqrt{2s_2 a} = \sqrt{2\cdot 60\cdot 1.125\cdot 10^{11}} = 3.67\cdot 10^6\ \frac{\mathrm{m}}{\mathrm{s}}.$$

Acceleration from v_1 to v_2 takes time:

$$t_2 = \frac{v_2 - v_1}{a} = \frac{3.67\cdot 10^6 - 3\cdot 10^6}{1.125\cdot 10^{11}} = 5.99\cdot 10^{-6}\ \mathrm{s},$$

$$t = t_1 + t_2 = 2.67\cdot 10^{-5} + 5.99\cdot 10^{-6} = 3.27\cdot 10^{-5}\ \mathrm{s}.$$

3. A jet plane lands with a speed of 100 m/s and can accelerate at a maximum rate of-5.00 m/s squared as it comes to rest. (a) From the instant, the plane touches the runway, what is the minimum time interval needed before it can come to rest? (b). Can this plane land on a small tropical island airport where the runway is 0.800 km long?

Solution

a) The minimum time interval needed before the plane comes to rest:

$$t = \frac{v}{a} = \frac{100}{5} = 20\ s.$$

b) Determine how long the plane will go before coming to rest:

$$s = \frac{\Delta v^2}{2a} = \frac{(0-100)^2}{2 \cdot 5} = 1000 \text{ m or } 1 \text{ km}.$$

The tropical island's airport runway is not enough.

Answer:

1. a) $21.82\ \frac{\text{mi}}{\text{h}\cdot\text{s}}$ or $9.75\ \frac{\text{m}}{\text{s}^2}$, b) $22.24\ \frac{\text{mi}}{\text{h}\cdot\text{s}}$ or $9.94\ \frac{\text{m}}{\text{s}^2}$, c) $3.26\ \frac{\text{mi}}{\text{h}\cdot\text{s}}$ or $1.46\ \frac{\text{m}}{\text{s}^2}$.
2. a) $1.125 \cdot 10^{11}\ \frac{\text{m}}{\text{s}^2}$, b) $3.27 \cdot 10^{-5}$ s.
3. a) 20 s, b) no.