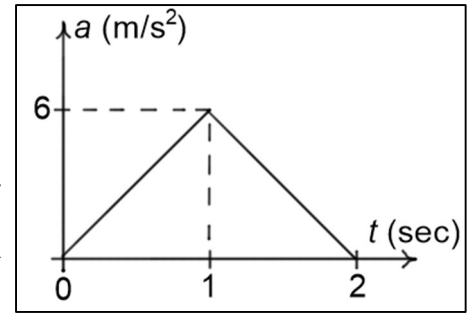


Elementary Dynamics

Exercises #1 – Rectilinear Motion Profiles

1. The cart travels along the horizontal path. It has an acceleration as shown in the diagram. The initial position and velocity of the cart are $s_0 = 0$ (ft) and $v_0 = 2$ (ft/sec). Find the following: a) $v(t)$ the velocity of the cart for $0 \leq t \leq 1$ (sec), b) $s(t)$ the position of the cart for $0 \leq t \leq 1$ (sec), c) $v(t)$ the velocity of the cart for $1 \leq t \leq 2$ (sec), and d) $s(t)$ the position of the cart for $1 \leq t \leq 2$ (sec).



Answers:

$$\begin{aligned} \text{a) } v(t) &= 2 + 3t^2 \text{ (ft/sec)} & 0 \leq t \leq 1 \text{ (sec); } & \text{b) } s(t) = 2t + t^3 \text{ (ft)} & 0 \leq t \leq 1 \text{ (sec)} \\ \text{c) } v(t) &= -4 + 12t - 3t^2 \text{ (ft/sec)} & 1 \leq t \leq 2 \text{ (sec); } & \text{d) } s(t) = 2 - 4t + 6t^2 - t^3 \text{ (ft)} & 1 \leq t \leq 2 \text{ (sec)} \end{aligned}$$

2. A car travels along a horizontal path with an **acceleration** $a(s) = 20 - 3s$ (m/s²), where s is in meters. The **initial velocity** of the car is $v(0) = 30$ (m/s). Find the following: a) $v(s)$ the **velocity** of the car as a function of position s , b) the **velocity** of the car after it travels 10 (m), and c) d the **distance** required for the car to stop.

Answers:

$$\text{a) } v(s) = \sqrt{900 + 40s - 3s^2} \text{ (m/s); } \text{b) } v(10) = 31.6 \text{ (m/s); } \text{c) } d = 25.2 \text{ (m)}$$

3. A car travels along a horizontal path with an **acceleration** $a(v) = -\frac{1}{4}v^2$ (m/s²), where v is in meters per second. The **initial velocity** of the car is $v(0) = 16$ (m/s). Find $v(t)$ the **velocity** of the car as a function of time.

Answer: $v(t) = \frac{16}{4t + 1}$

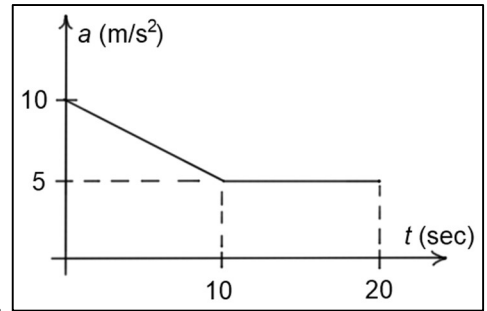
4. Accounting for aerodynamic drag, the acceleration of a car is $a(v) = 30 - \frac{v^2}{400}$ (ft/s²). If the car starts from rest, find the displacement of the car when its velocity is $v = 50$ (ft/s).

Answer: $s = 46.7$ (ft)

5. A car travels along a horizontal path with an **acceleration** $a(v) = -3v^{\frac{2}{3}}$ (m/s²), where v is in **meters per second**. Find $v(s)$ the **velocity** of the car as a function of s (the distance traveled). The **initial velocity** of the car is 27 (m/s) when $s = 0$.

Answer: $v(s) = (81 - 4s)^{\frac{3}{4}}$ (m/s)

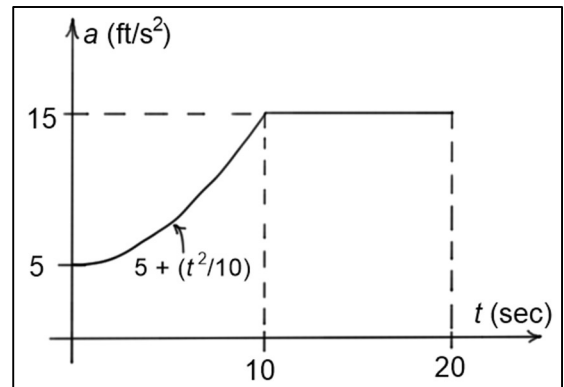
6. A cart travels along a horizontal path with acceleration $a(t) = 10 - \frac{1}{2}t$ (m/s^2) for $0 \leq t \leq 10$ (s) and **constant** acceleration $a = 5$ (m/s^2) for $10 \leq t \leq 20$ (sec). The initial position of the cart is $s(0) = 0$ (m), and its initial velocity is $v(0) = 3$ (m/s). Find the following: a) $v(t)$ the velocity of the cart as a function of time for $0 \leq t \leq 10$ (s), b) $s(t)$ the displacement of the cart as a function of time for $0 \leq t \leq 10$ (s), c) $v(t)$ the velocity of the cart as a function of time for $10 \leq t \leq 20$ (s), and d) $s(t)$ the displacement of the cart as a function of time for $10 \leq t \leq 20$ (s).



Answers:

$$\begin{aligned} \text{a) } v(t) &= 3 + 10t - \frac{1}{4}t^2 \text{ (m/s)} & 0 \leq t \leq 10 \text{ (s); } & \text{b) } s(t) = 3t + 5t^2 - \frac{1}{12}t^3 \text{ (m)} & 0 \leq t \leq 10 \text{ (s)} \\ \text{c) } v(t) &= 5t + 28 \text{ (m/s)} & 10 \leq t \leq 20 \text{ (s); } & \text{d) } s(t) = \frac{5}{2}t^2 + 28t - 83.3 \text{ (m)} & 10 \leq t \leq 20 \text{ (s)} \end{aligned}$$

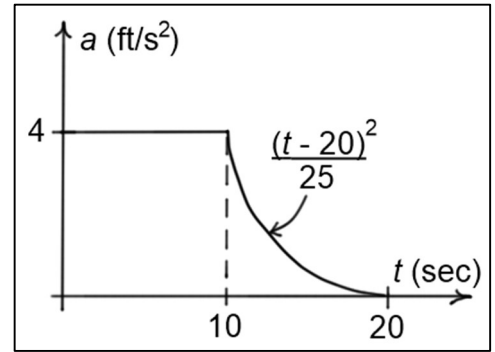
7. A car travels along a horizontal path and has **acceleration** $a = 5 + \frac{1}{10}t^2$ (ft/s^2) for $0 \leq t \leq 10$ (sec) and **constant** acceleration $a = 15$ (ft/s^2) for $10 \leq t \leq 20$ (sec). The car starts from **rest** at $s = 0$ when $t = 0$. Find the following: a) $v(t)$ the velocity of the car as a function of time for $0 \leq t \leq 10$ (sec), b) $s(t)$ the displacement of the car as a function of time for $0 \leq t \leq 10$ (sec), c) $v(t)$ the velocity of the car as a function of time for $10 \leq t \leq 20$ (sec), and d) $s(t)$ the displacement of the car as a function of time for $10 \leq t \leq 20$ (sec).



Answers:

$$\begin{aligned} \text{a) } v(t) &= 5t + \frac{t^3}{30} \text{ (ft/s)} & 0 \leq t \leq 10 \text{ (sec); } & \text{b) } s(t) = \frac{5}{2}t^2 + \frac{t^4}{120} \text{ (ft)} & 0 \leq t \leq 10 \text{ (sec)} \\ \text{c) } v(t) &= 15t - 66.7 \text{ (ft/s)} & 10 \leq t \leq 20 \text{ (sec); } & \text{d) } s(t) = 7.5t^2 - 66.7t + 250.0 \text{ (ft)} & 10 \leq t \leq 20 \text{ (sec)} \end{aligned}$$

8. A car travels along a horizontal path and has **constant** acceleration of $a = 4 \text{ (ft/s}^2\text{)}$ for $0 \leq t \leq 10 \text{ (sec)}$ and acceleration of $a(t) = \frac{1}{25}(t-20)^2 \text{ (ft/s}^2\text{)}$ for $10 \leq t \leq 20 \text{ (sec)}$. The car starts from **rest** at $s = 0$. Find the following: a) $v(t)$ the velocity of the car as a function of time for $0 \leq t \leq 10 \text{ (sec)}$, b) $s(t)$ the displacement of the car as a function of time for $0 \leq t \leq 10 \text{ (sec)}$, c) $v(t)$ the velocity of the car as a function of time for $10 \leq t \leq 20 \text{ (sec)}$, and d) $s(t)$ the displacement of the car as a function of time for $10 \leq t \leq 20 \text{ (sec)}$.



Answers:

- a) $v(t) = 4t \text{ (ft/s)}$ $0 \leq t \leq 10 \text{ (sec)}$; b) $s(t) = 2t^2 \text{ (ft)}$ $0 \leq t \leq 10 \text{ (sec)}$
c) $v(t) = \frac{1}{75}(t-20)^3 + 53.3 \text{ (ft/s)}$ $10 \leq t \leq 20 \text{ (sec)}$
d) $s(t) = \frac{1}{300}(t-20)^4 + 53.3t - 367 \text{ (ft)}$ $10 \leq t \leq 20 \text{ (sec)}$