

19th May, 2020

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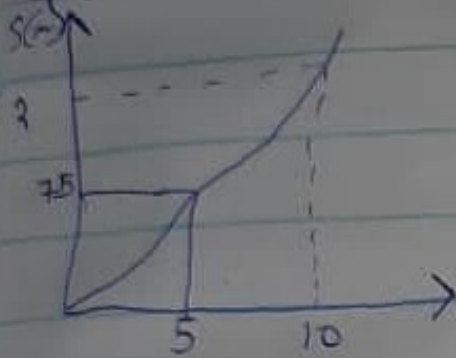
18/ENG05/007

Mechatronics Engineering

Engineering Mechanics
(F12-12)

Question 1: Construct the v-t and a-t graph

Solutions: For v-t



$$v = \frac{ds}{dt}$$

$$\text{at } 0 \leq t \leq 5$$

$$s = 3t^2$$

$$v = 6t$$

$$\text{at } t = 5; v = 30 \text{ m/s}$$

$$\text{at } 5 \leq t \leq 10$$

$$s = 30t - 75$$

$$v = 30$$

$$\text{at } t = 10 \text{ s, } v = 30 \text{ m/s}$$

For a-t

$$a = \frac{dv}{dt}$$

$$\text{at } 0 \leq t \leq 5$$

$$v = 6t$$

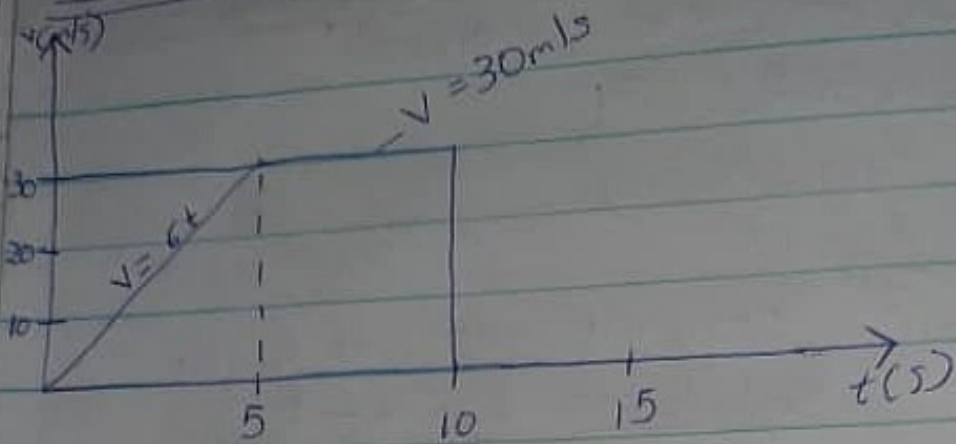
$$a = 6 \text{ m/s}^2$$

$$\text{at } 5 \leq t \leq 10$$

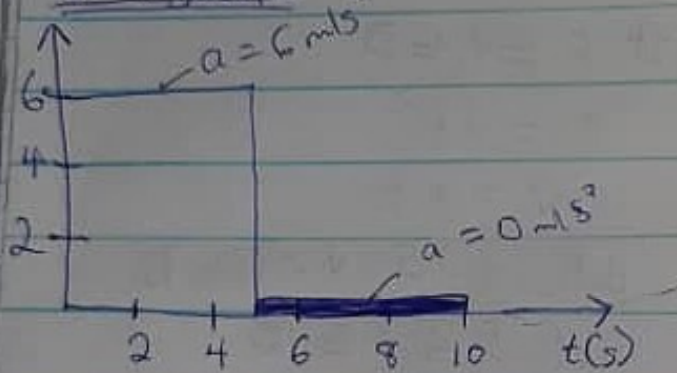
$$v = 30 \text{ m/s}$$

$$a = 0 \text{ m/s}^2$$

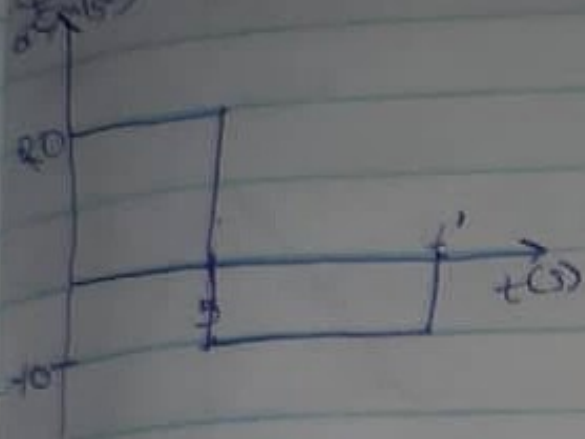
V-T graph



a-t graph



Question 2 (F12-13): Construct the v-t graph for $0 \leq t \leq t'$



Solution

at $0 \leq t \leq 5$

$$dv = a dt$$

$$\int_0^v dv = \int_0^5 20 dt$$

$$v = 20t$$

at $t = 5s$

$$v = 20(5) = 100 \text{ m/s}$$

at $5 \leq t \leq t'$

$$a = -10$$

$$\int_{100}^v dv = \int_5^t -10 dt$$

$$v \Big|_{100}^v = -10t \Big|_5^t$$

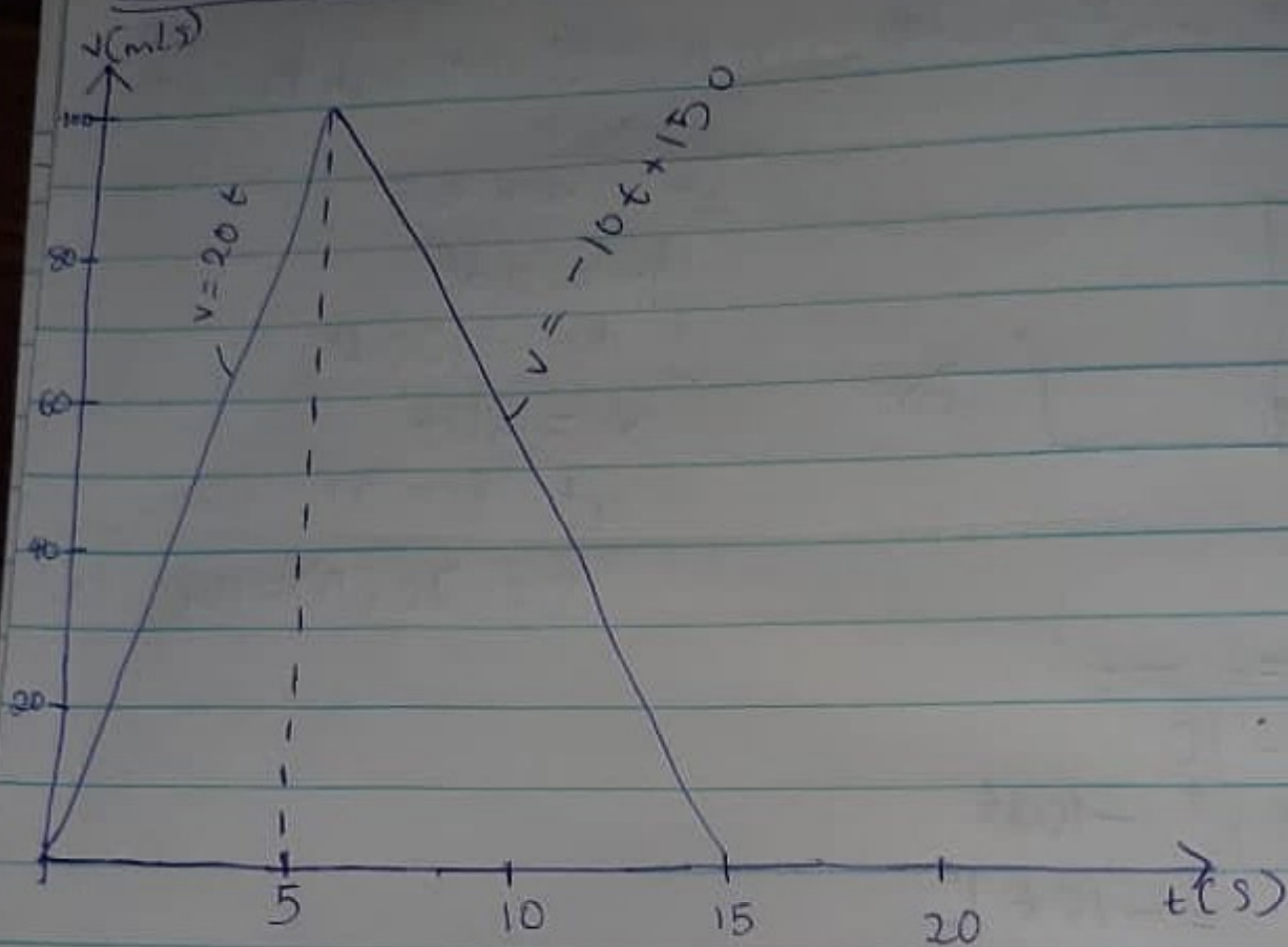
$$v - 100 = -10t + 50$$

$$v = -10t + 150$$

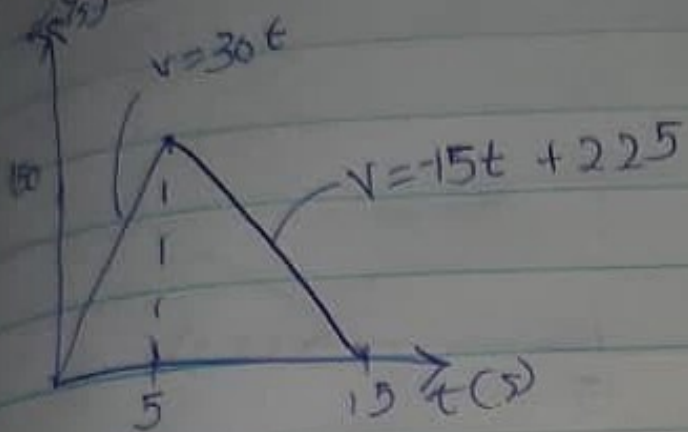
at $t = t'$ and $v = 0$

$$t = \frac{0 - 150}{-10} = \frac{-150}{-10} = 15s$$

v-t graph



Question 3 (F12-14): Construct the $s-t$ graph
 $0 \leq t \leq 15$ s - find the total distance



Solution

$$\int_0^5 ds = \int_0^5 v dt$$

$$0 \leq t \leq 5$$

$$v = 30t$$

$$\int_0^5 ds = \int_0^5 (30t) dt$$

$$s = 15t^2$$

$$\text{at } t=5 \text{ s, } s = 15(5)^2 = 375 \text{ m}$$

$$\text{at } 5 \leq t \leq 15$$

$$v = -15t + 225$$

$$\int_{375}^s ds = \int_5^t (-15t + 225) dt$$

$$s - 375 = -\frac{15}{2}t^2 + 225t \Big|_5^t$$

$$s - 375 = -\frac{15}{2}t^2 + 225t - \left(-\frac{15}{2}(5^2) + 225(5)\right)$$

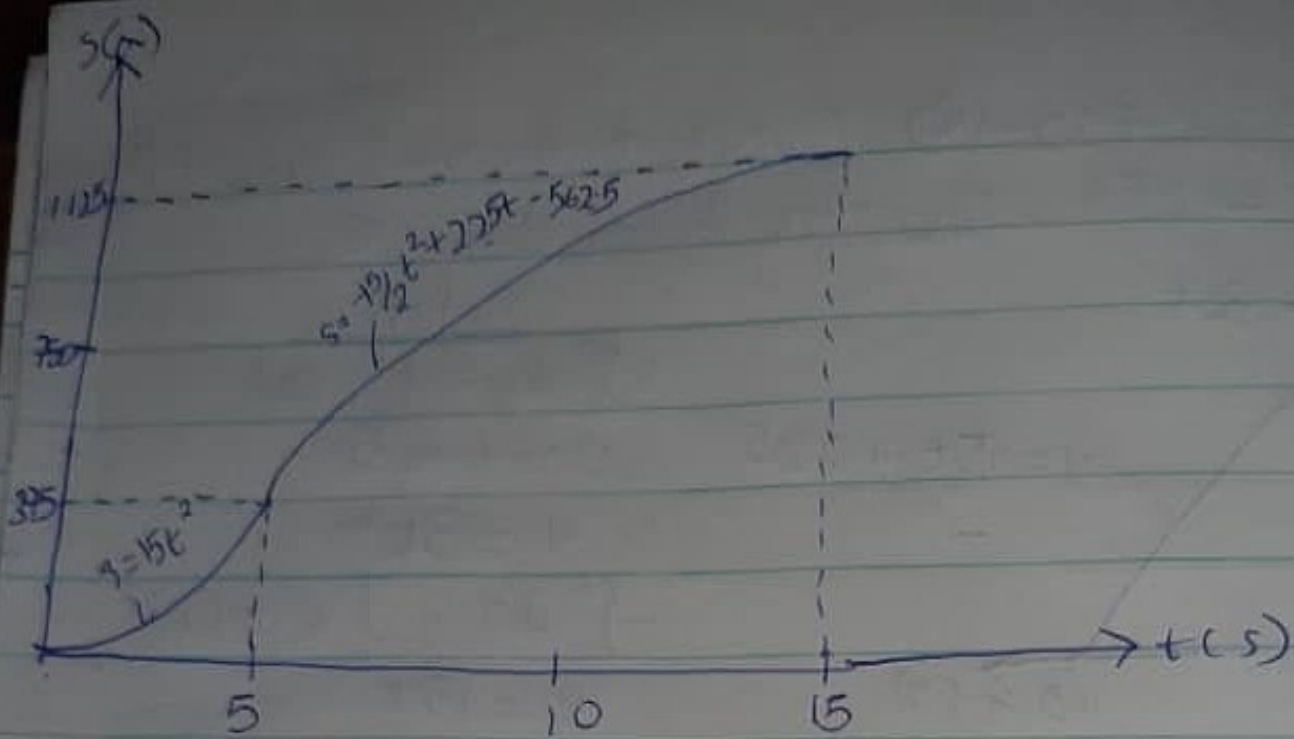
$$s - 375 = -\frac{15}{2}t^2 + 225t - 937.5$$

$$s = -\frac{15}{2}t^2 + 225t - 562.5$$

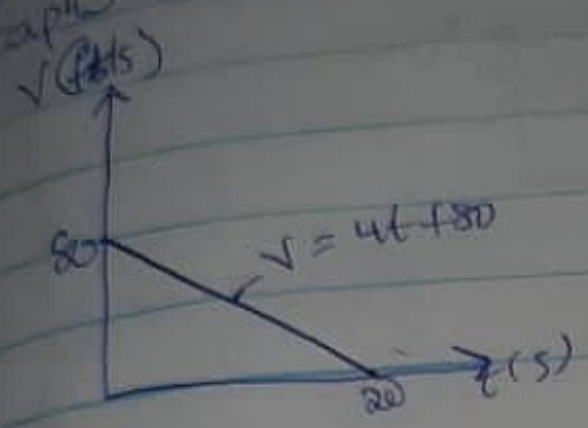
when $t = 15$ seconds

$$s = -\frac{15}{2}(15^2) + 225(15) - 562.5$$

$$s = 1125 \text{ m}$$



Question 4 (F12-10): Consider the $s-t$ and $a-t$ graphs (take $s=0$ when $t=0$)



Solution

For $a-t$

$$a = dv/dt$$

$$v = -4t + 80, \quad t = 20$$

$$a = -4 \text{ m/s}$$

For $s-t$

$$v = ds/dt$$

$$\int_0^s ds = \int_0^t v dt$$

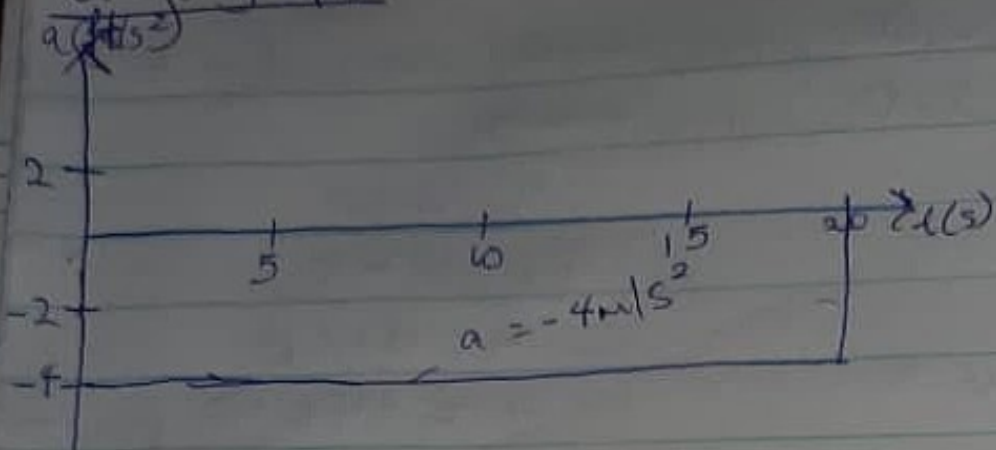
$$s = \int (-4t + 80) dt$$

$$s = -2t^2 + 80t$$

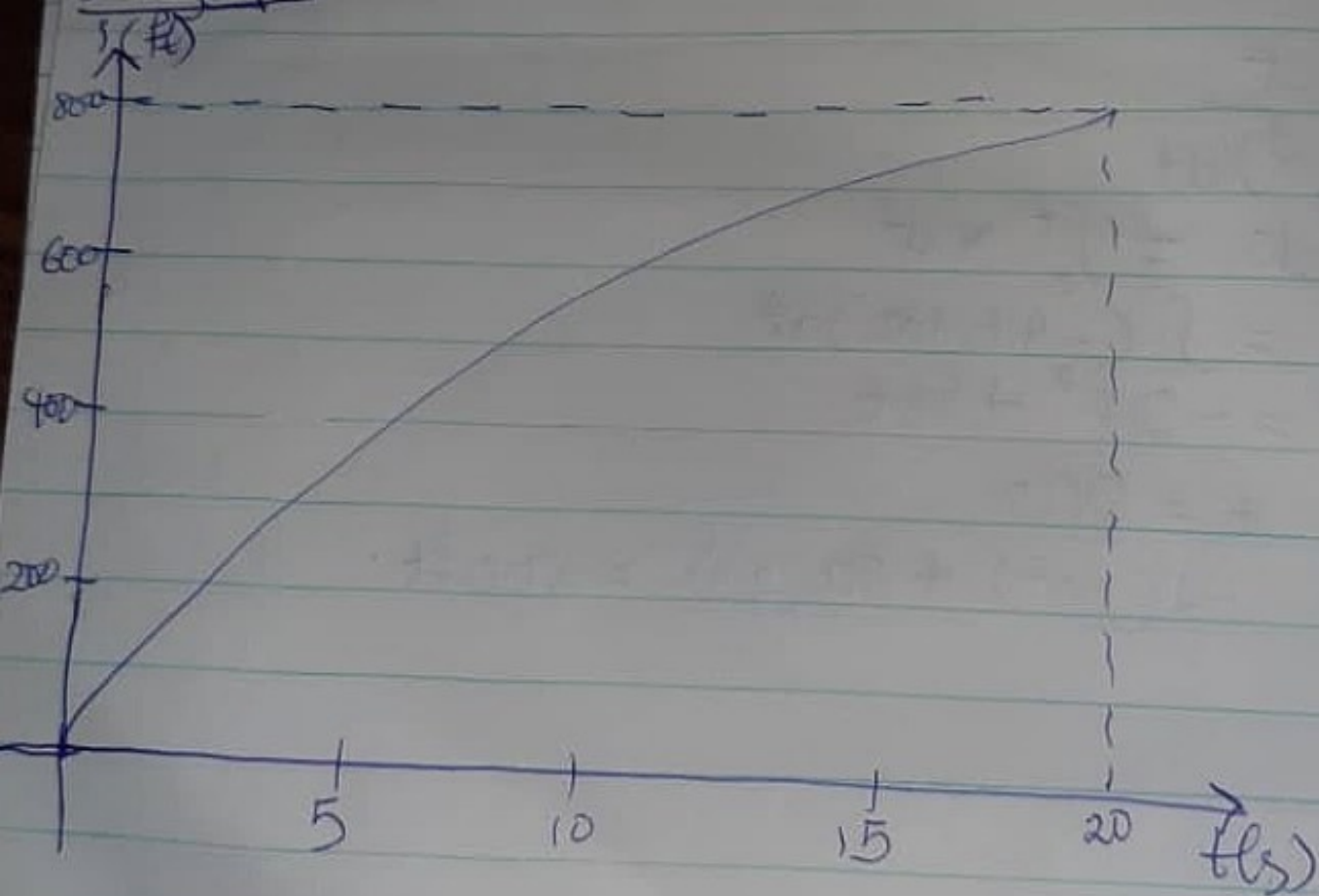
When $t = 20\text{s}$

$$s = -2(20^2) + 80(20) = 800 \text{ ft.}$$

a-t graph

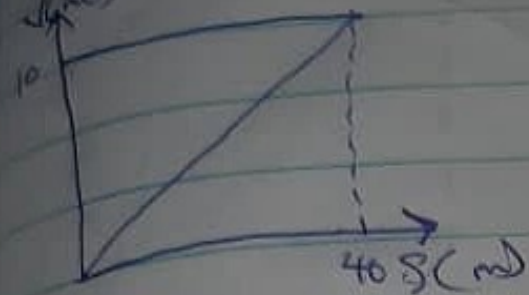


s-t graph



Question 5 (F12-10)

Construct the $a-s$ graph



Solution

$$v dv = a ds$$

$$v = 0.25s$$

$$\frac{dv}{ds} = 0.25$$

$$dv = 0.25 ds$$

$$a ds = v dv$$

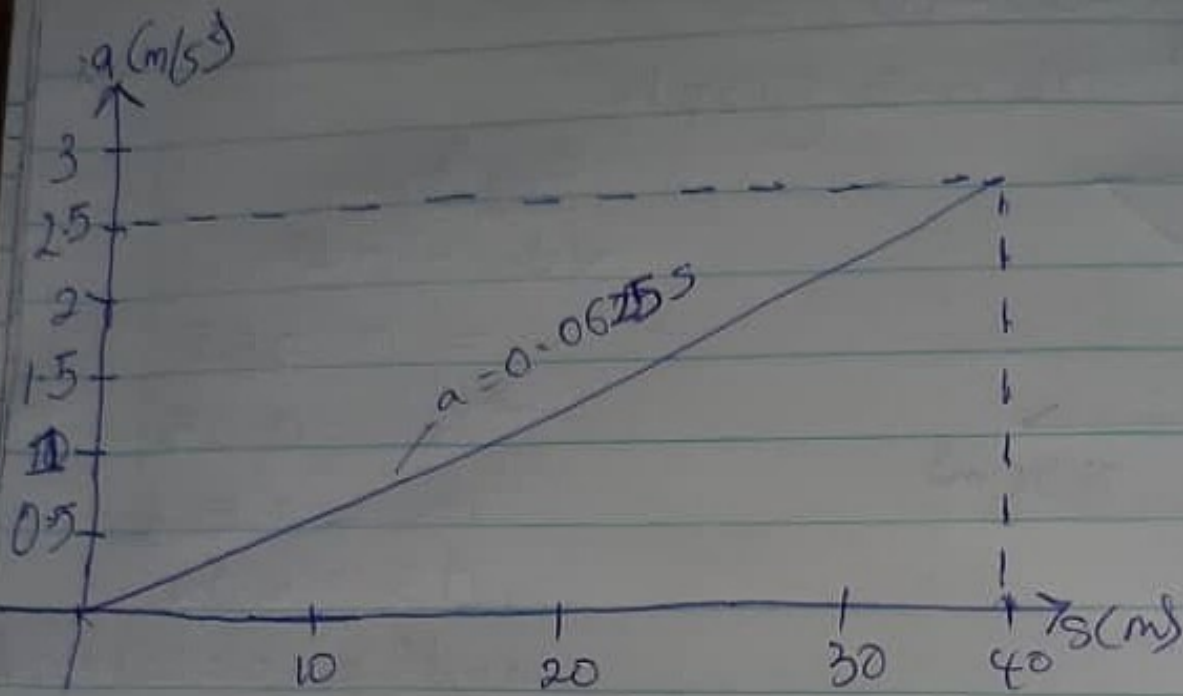
$$a \cdot ds = (0.25s) \cdot (0.25 ds)$$

$$a = 0.0625s$$

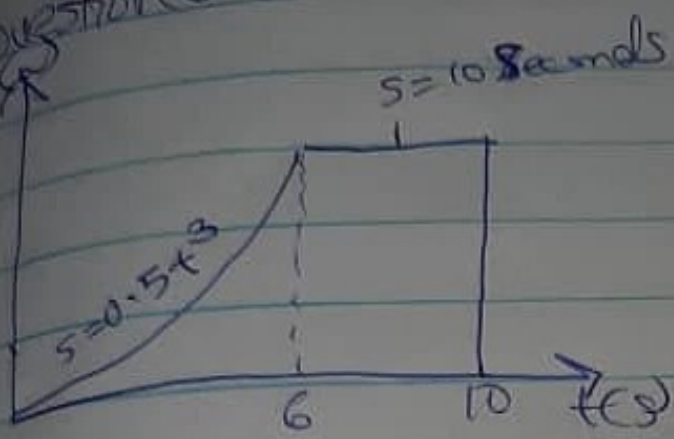
$$\text{at } s = 40, a = 0.0625(40)$$

$$a = 2.5 \text{ m/s}^2$$

a-s graph



Question (F12-9) : Construct the $v-t$ graph
 Solution



For $v-t$

$$0 \leq t \leq 6$$

$$v = \frac{ds}{dt}, s = 0.5t^3$$

$$v = 1.5t^2$$

$$\text{at } t = 6s$$

$$v = 1.5(6^2) = 54$$

$$6 \leq t \leq 10,$$

$$v = 0$$

v-t graph

