

Motion in One Dimension

ch2 - Part 2

Since velocity (and speed) can also change, we need to define another quantity to describe the change in velocity:

تتغير
توصف التغير في السرعة
كيفية

$$\text{Average Acceleration} = \bar{a} = \frac{\text{Change in Velocity}}{\text{Time taken for this change}}$$

So $\bar{a}$ can be positive or negative.

The SI unit for $\bar{a}$ is m/s^2

We will be studying cases of constant (uniform) acceleration only. So in our case $\bar{a} = a$.

$$a = \square$$

$$\bar{a}$$

① Acceleration

$$a = +$$

ex

$$20 \text{ m/s} \rightarrow 50 \text{ m/s}$$

$$\Delta V = V - V_0 = 50 - 20 = +30$$

$$a = \frac{\Delta V}{t} = \frac{30}{t} = +$$

② Deceleration

$$a = -$$

$$50 \text{ m/s} \rightarrow 0 \text{ m/s}$$

$$\Delta V = V - V_0 = 0 - 50 = -50$$

$$a = \frac{\Delta V}{t} = \frac{-50}{t} = -$$

③ Constant speed

$$V_0 = 50 \text{ m/s}$$

$$V = 50 \text{ m/s}$$

$$\Delta V = 50 - 50 = 0$$

$$a = \frac{\Delta V}{t} = 0$$

السرعة ← معدل التغير في الجاذبة أو الإزاحة

$$\bar{a} = \frac{\Delta V}{t} = \frac{\text{m/s}}{\text{s}} = \frac{\text{m}}{\text{s}^2}$$

طبيب بالنسبة لالتغير في السرعة

Acceleration (الإسالة)

$$a = \frac{\Delta V}{t}$$

$$\Delta V = V - V_0$$

$V \rightarrow$ Final velocity السرعة النهائية

$V_0 \rightarrow$ initial velocity السرعة الابتدائية

Motion in One Dimension

To derive the equations governing the motion of objects under constant acceleration, we will use the following symbols:

x_0 = initial position

x = final position

v_0 = initial velocity

v = final velocity

a = acceleration (constant)

t = time taken

$\bar{v}$ = average velocity

المزاحة = $(x - x_0)$
الموضع
الابتدائي

السرعة
الابتدائية = $(v - v_0)$
السرعة
النهائية

الزمن = t

السرعة المتوسطة = $\bar{v}$

Motion in One Dimension

The five Kinematic Equations are (are derived in the lecture):

$$\bar{v} = \frac{1}{2}(v + v_0) \quad (1)$$

$$x = x_0 + \bar{v} t \quad (2)$$

$$v = v_0 + at \quad (3)$$

$$x = x_0 + v_0 t + \frac{1}{2}at^2 \quad (4)$$

$$v^2 = v_0^2 + 2a(x - x_0) \quad (5)$$

Eq. (4) is quadratic in time and it also includes linear term in time. It is not easy to solve this equation if you are trying to calculate time. You should try to avoid using Eq. (4) when calculating time. I will explain this with specific examples.

معادلة جداول

معادلات الحركة

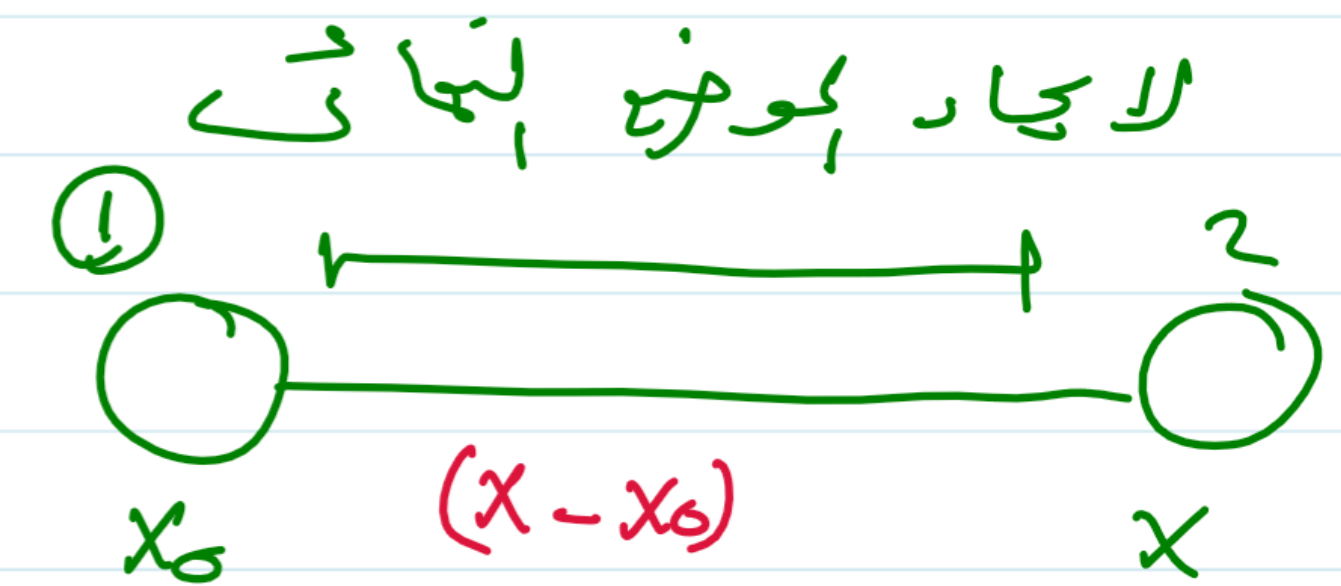
$$\textcircled{1} \quad \bar{v} = \frac{v + v_0}{2} \quad \text{السرعة المتوسطة}$$

$$= \frac{\text{Total distance}}{\text{Total time}}$$

$$\textcircled{2} \quad x = x_0 + \bar{v} t$$

$$(x - x_0) = \bar{v} t \quad \text{الازاحة الكلية}$$

From eq. 1



$$\textcircled{3} \quad v = v_0 + at \rightarrow \text{الاجار السرعي النهائي من حالة عدم معرفة الازاحة}$$

$$\textcircled{4} \quad x = x_0 + v_0 t + \frac{1}{2}at^2$$

$$\text{الازاحة الكلية} \quad (x - x_0) = v_0 t + \frac{1}{2}at^2$$

الازاحة الكلية من حالة عدم معرفة السرعة النهائية

v

$\textcircled{5}$

معادلة الجداول

$$v^2 = v_0^2 + 2a(x - x_0)$$

السرعة النهائية او (x) الموضع من حالة عدم معرفة

Time (t)

Example 2

A car accelerates uniformly from 14 m/s to 22 m/s in 6.0 s.

- (a) How far did it travel in this time? ✓
(b) What was its acceleration? ✓
(c) If it continues at this acceleration, what distance it will travel when its speed reaches 30 m/s?

Ans: (a) 108 m. (b) 1.33 m/s² (c) 264 m.

□ → (14 m/s → 22 m/s)
t = 6 s

$V_0 = 14 \text{ m/s}$
 $V = 22 \text{ m/s}$

Ⓐ (X - X₀)

$X - X_0 = \bar{V} t = 18 \times 6 = 108 \text{ m}$

$\bar{V} = \frac{V + V_0}{2} = \frac{22 + 14}{2} = 18 \text{ m/s}$

9 → m/s² وحدة

Ⓑ $a = ? = \frac{\Delta V}{t} = \frac{V - V_0}{t} = \frac{22 - 14}{6} = \boxed{\frac{4}{3}} \text{ m/s}^2$

Ⓒ $V_0 \rightarrow 14 \text{ m/s} \xrightarrow{a = 4/3} 22 \text{ m/s} \xrightarrow{a = 4/3} 30 \text{ m/s} \rightarrow V$

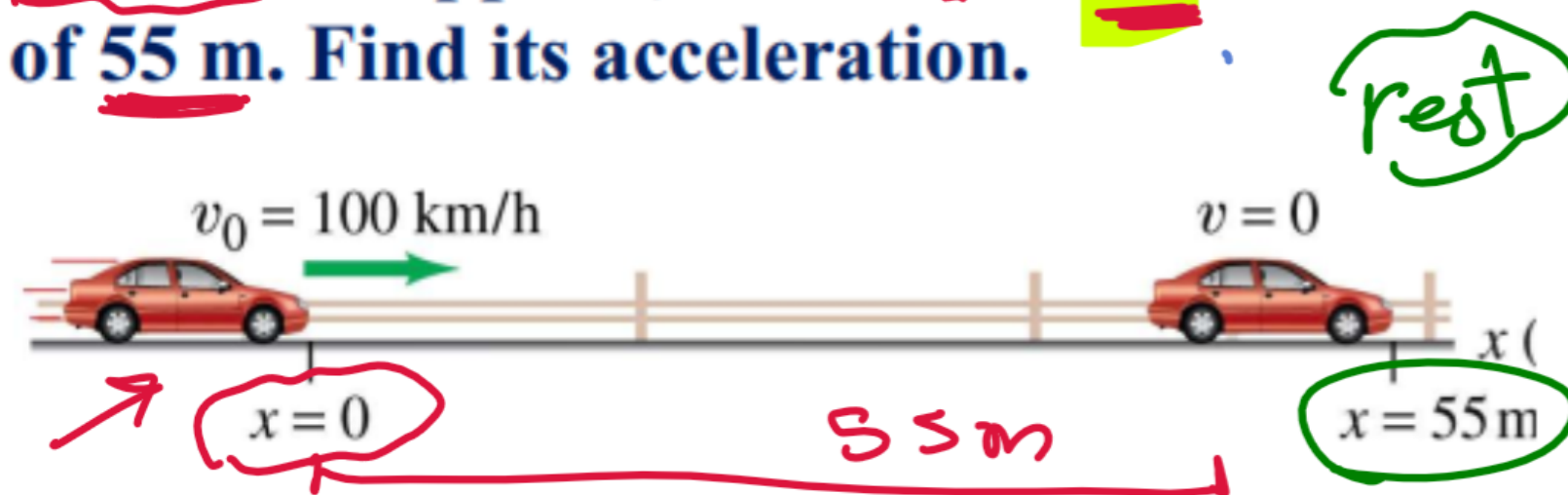
$V^2 = V_0^2 + 2a(X - X_0)$

$(30)^2 = (14)^2 + 2 \times \frac{4}{3} (X - X_0)$

$(X - X_0) = 264 \text{ m} \neq$

Example 3:

A car travelling at a speed of 100 km/h. When brakes are applied, it comes to rest in a distance of 55 m. Find its acceleration.



Ans: $a = -7.0 \text{ m/s}^2$

بدأت تستخدم قرائل السرعة وبالتالي
المترقب انه السرعة تنف وتصل مرحلة الكبح (rest)

$$\begin{cases} v_0 = 100 \text{ km/h} \times \frac{5}{18} = 27.77 \text{ m/s} \\ v = 0 \end{cases} \quad \text{و} \quad (55)^{\text{m}} = (x - x_0)$$

للازم تراسي الوحدات

$$v^2 = v_0^2 + 2a(x - x_0)$$

$$0 = (27.77)^2 + 2(9) \times 55$$

$$a = \frac{-(27.77)^2}{2 \times 55} = -7 \text{ m/s}^2 \quad \#$$

↓
Deceleration
↔

Example 4:

A car moving at a constant velocity travels 120 m in 5 s. If the brakes are applied, it comes to rest in 4 s. How far the car travel in stopping after the brakes were applied?

Ans: 48 m

$$a = \frac{\Delta v}{t} = \frac{v - v_0}{t} = \frac{0 - 24}{4} = -6 \text{ m/s}^2$$

$$v^2 = v_0^2 + 2a(x - x_0)$$

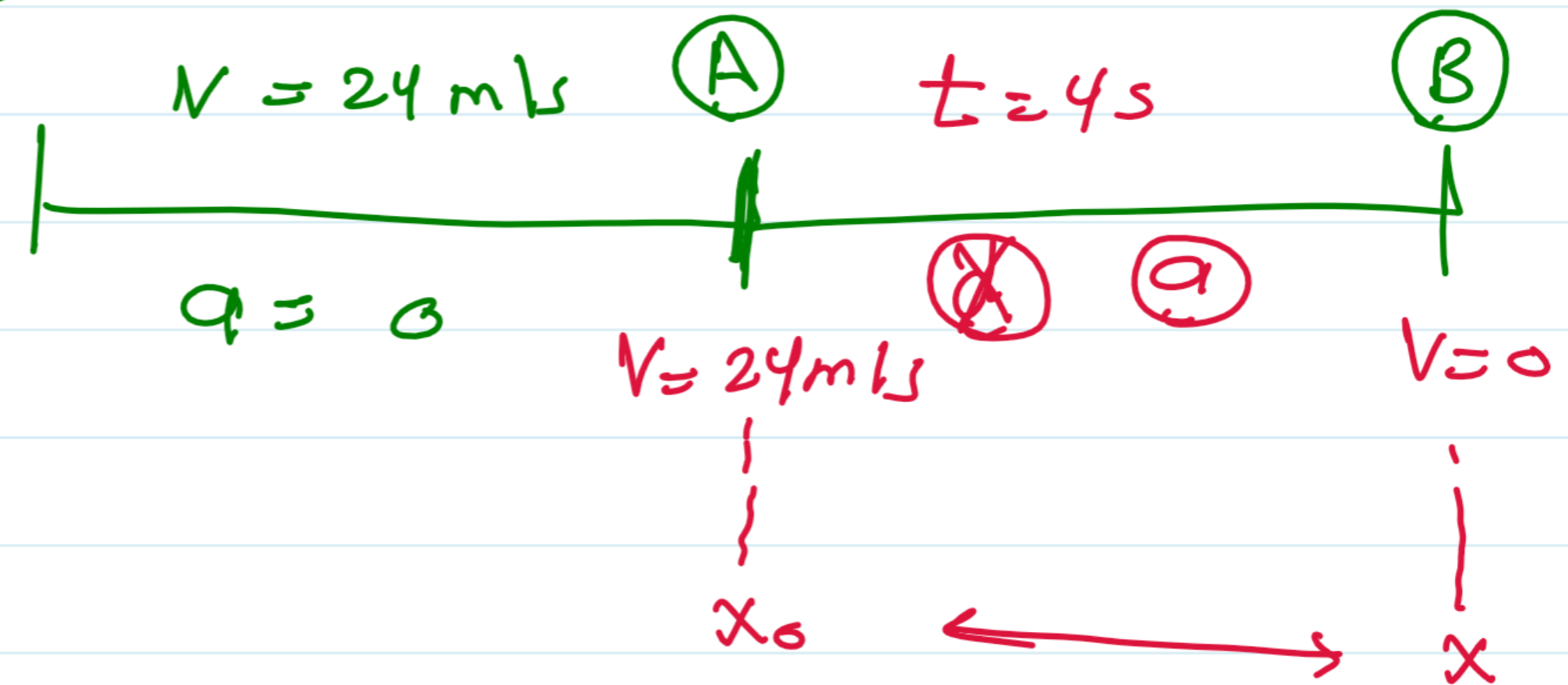
$$0 = (24)^2 - 2 \times 6 (x - x_0)$$

$$(x - x_0) = \frac{-(24)^2}{-2 \times 6} = 248 \text{ m}$$

$$v_0 = \frac{d}{t} = \frac{120}{5} = 24 \text{ m/s} \checkmark$$

$t = 4 \text{ s}$ → الزمن الذي آتته للدور في حالة كبح

$$v = 0 \checkmark$$



Example 5:

A plane must reach a speed of 40 m/s for takeoff. The plane can accelerate at a rate of 3.0 m/s². How long a runway is needed?

Ans: 267 m

المسافة

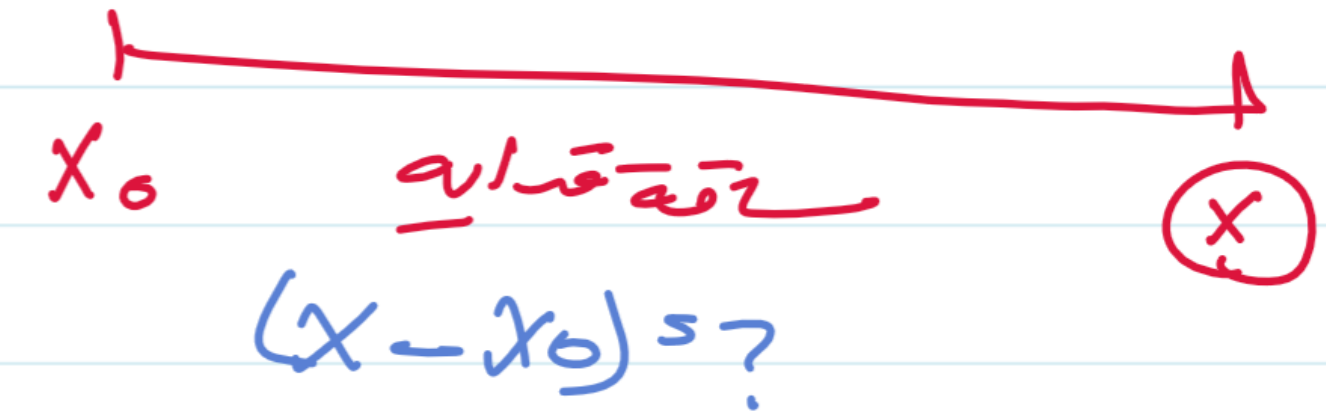
المسافة التي يقطعها الطائرة قبل أن تكتسب سرعة 40 م/ث

① $V_0 = 0$

$a = 3 \text{ m/s}^2$

② $V = 40 \text{ m/s}$

السرعة المطلوبة



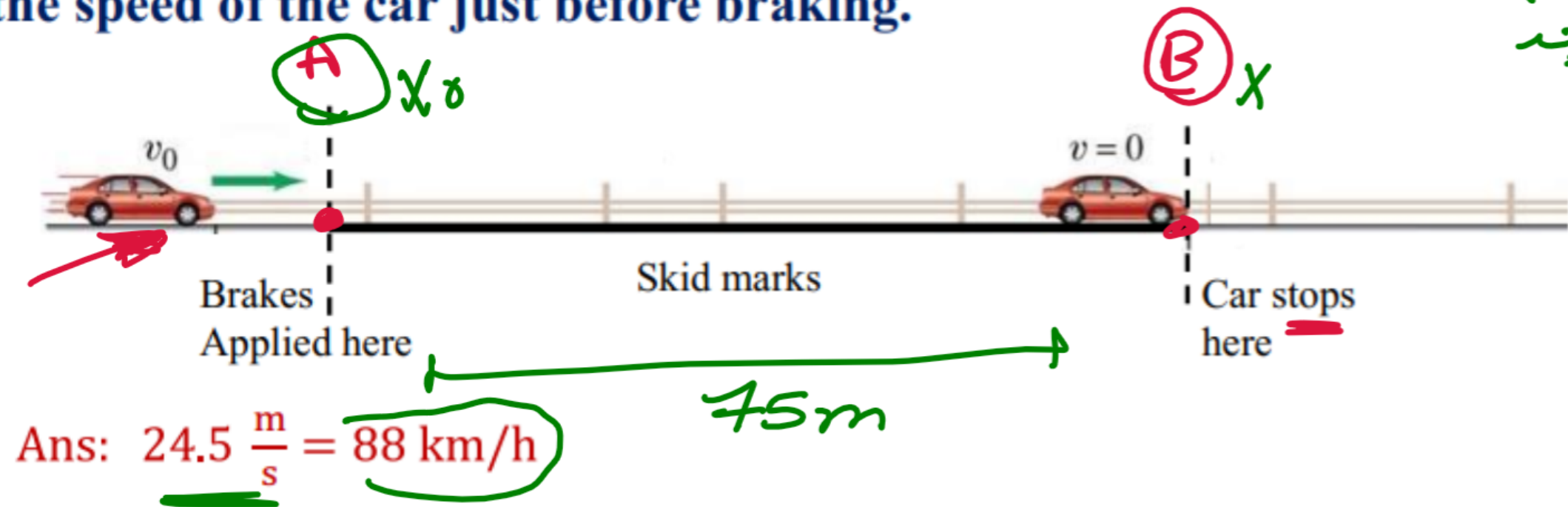
$$V^2 = V_0^2 + 2a(x - x_0)$$

$$(40)^2 = (0) + 2 \times 3 \times (x - x_0)$$

$$x - x_0 = \frac{(40)^2 - 0}{6} = 267 \text{ m} \quad \#$$

Example 6:

In coming to a stop, a car leaves skid marks 75 m long on the highway. Assuming constant deceleration of 4.0 m/s^2 , estimate the speed of the car just before braking.

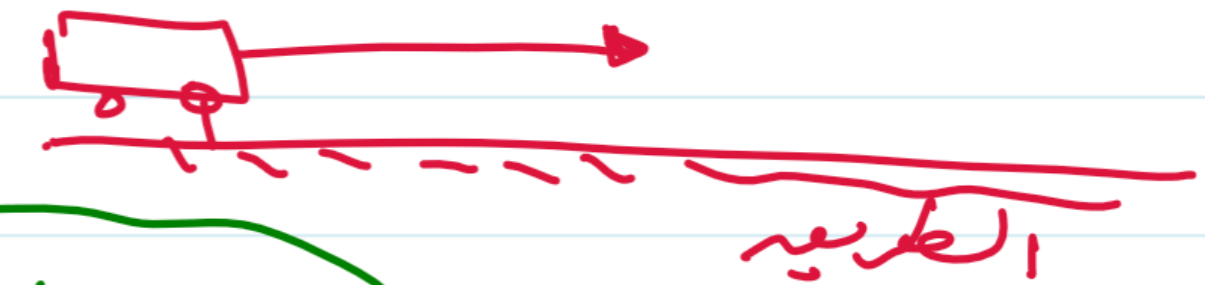


حساب
السرعة
الابتدائية

$$v_0 = ?$$

$$v = 0$$

$$a = -4 \text{ m/s}^2$$



$$(x - x_0) = 75 \text{ m}$$

$$v^2 = v_0^2 + 2a(x - x_0)$$

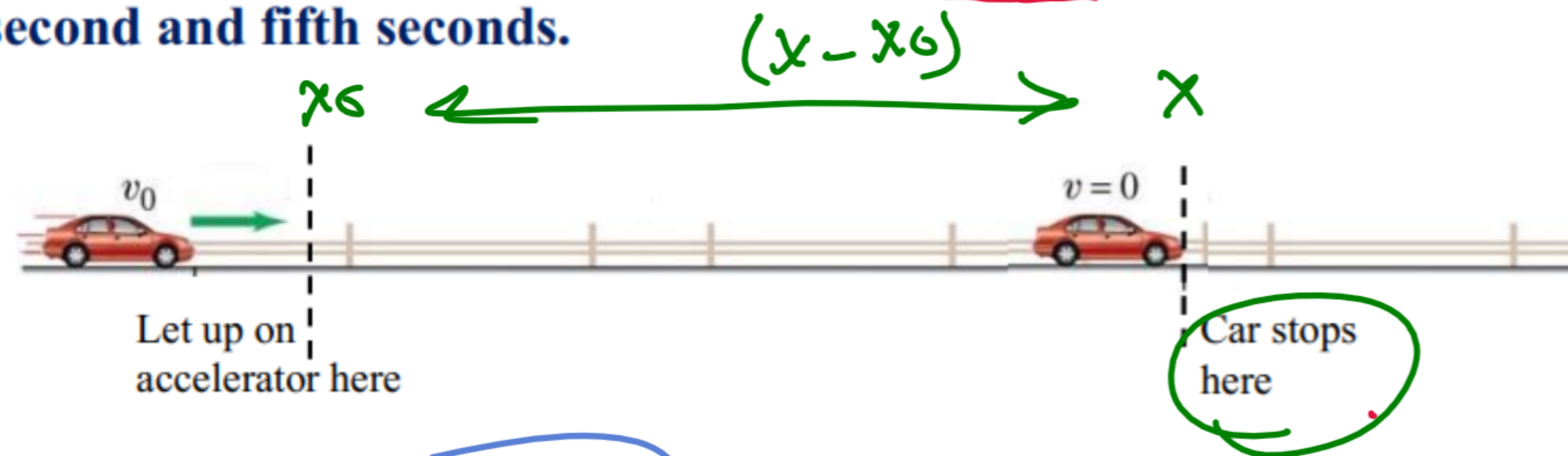
$$0 = (v_0)^2 - 2 \times 4 (75)$$

$$v_0^2 = 8 \times 75 = 600$$

$$v_0 = \sqrt{600} = 24.49 \approx 24.5 \text{ m/s} \xrightarrow{\times 1.8/\text{s}} 88 \text{ km/h}$$

Example 7:

A car travelling at 75 km/h slows down at a constant rate of 0.5 m/s² just by "letting up on the accelerator." Calculate (a) the distance the car "coasts" before it stops, and (b) the distance it travels during the second and fifth seconds.



Ans: (a) 433 m (b) 57.2 m

$$v_0 = 75 \times \frac{5}{18} = 20,833 \text{ m/s}$$

$$a = -0,5 \text{ m/s}^2 \quad \rightarrow v = 0$$

$$(9) \quad v^2 = v_0^2 + 2a(x - x_0)$$

$$0 = (20,83)^2 - 2 \times 0,5(x - x_0)$$

$$(x - x_0) = \frac{-(20,83)^2}{-2 \times 0,5} = 434,027 \text{ m}$$

(b)

From $t = 2 \rightarrow t = 5$

المسافة التي تسيرها السيارة من الثانية (2) إلى الثانية (5)

$$\Delta x = x(t) - x(t_0)$$

$$x = v_0 t + \frac{1}{2} a t^2$$

$$x = 20,83 t - \frac{1}{2} \times \frac{1}{2} t^2$$

قيمة x عند لحظة زمنية t

$$t = 2 \rightarrow x(2) = 20,83 \times 2 - \frac{1}{4} \times (2)^2$$

$$= 40,66$$

$$t = 5 \rightarrow x(5) = 20,83 \times 5 - \frac{1}{4} \times (5)^2$$

$$= 97,92$$

$$\Delta x = x(5) - x(2)$$

$$= 97,92 - 40,66 = 57,26 \text{ m} \quad \#$$

Example 8:

Sarah starts from rest at home and accelerates at a rate of 0.7 m/s^2 for a distance of 600 m. Then she drives at that speed for 5 minutes to reach her uncle's house. (a) How far is her uncle's house from her home? (b) What was her average speed?

Ans: (a) Distance = 9300 m (b) Average speed = 27 m/s

(a)

$V = ??$

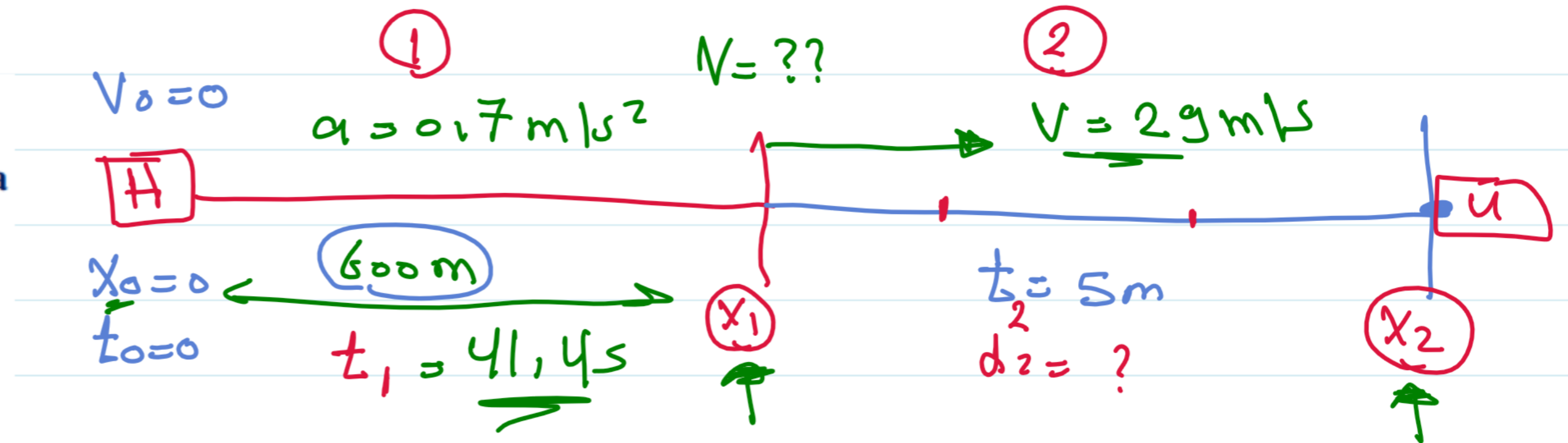
$$V^2 = V_0^2 + 2a(X_1 - X_0)$$

$$V^2 = 0 + 2 \times 0.7 (600)$$

$$V^2 = 840 \text{ m/s}$$

$$V = \sqrt{840} = 28.9 \text{ m/s}$$

$$V \approx 29 \text{ m/s}$$



حالة المرحلة الأولى

(b)

$$V = V_0 + a(t)$$

$$t = \frac{29 - 0}{0.7} = 41.4 \text{ s}$$

حالة المرحلة الثانية

سرعة ثابتة $\leftarrow$ $a = 0$ في هذه الحالة

$$V = V_0 = \bar{V}$$

السرعة المتوسطة = السرعة الابتدائية = السرعة الختامية

$$\frac{(x - x_0)}{\downarrow} = \bar{v} t$$

$$t = 5 \text{ m} = 5 \times 60 = 300 \text{ s}$$

$$(x_2 - x_1) = \bar{v} t$$

$$(x_2 - x_1) = 2g \times 300 = 8700 \text{ m} \quad \left(\text{از ارتفاع 5 متر، آزاد افتادن} \right)$$

a) Total distance From $(x_0 \rightarrow x_2) = 600 + 8700 = 9300 \text{ m}$

b) Average speed = $\frac{\text{Total distance}}{\text{Total time}}$

$$= \frac{9300}{41.4 + 300} \approx 27 \text{ m/s}$$