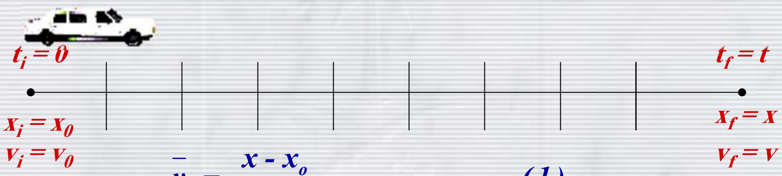
2.5 FINDING THE MOTION OF AN OBJECT

Derivation of equations:

All equations that will be derived, are used to describe **ONLY** the motions with **constant acceleration**.



$$\bar{v} = \frac{x - x_o}{t} \qquad (1)$$

$$\bar{v} = \frac{v + v_o}{2} \qquad (2)$$

$$a = \frac{v_f - v_i}{t_f - t_i} = \frac{v - v_o}{t} \qquad (3)$$

From (3), we will get

$$a = \frac{v - v_o}{t}$$

$$v = v_o + at \qquad (4)$$

From (1),we will get

$$\bar{v} = \frac{x - x_o}{t} \Rightarrow x = x_o + \bar{v}t$$

Then, substitute the average velocity (above) with that from (2)

$$\Rightarrow x = x_o + \left(\frac{v + v_o}{2}\right)t$$

$$x - x_o = \frac{1}{2}(v + v_o)t \qquad (5)$$

From (5), substitute the v with that from (4)

$$\Rightarrow \quad x = x_o + \left(\frac{(v_o + at) + v_o}{2} \right) t$$

$$x - x_o = v_o t + \frac{1}{2} a t^2 \qquad (6)$$

From (5), substitute the t with that from (4)

$$\Rightarrow \quad x = x_o + \frac{1}{2}(v + v_o)\left(\frac{v - v_o}{a} \right)$$

$$\Rightarrow \quad x - x_o = \frac{1}{2a}(v + v_o)(v - v_o)$$

$$\Rightarrow \quad v^2 - v_o^2 = 2a(x - x_o)$$

$$v^2 = v_o^2 + 2a(x - x_o) \qquad (7)$$

103 Phys — Dr. Abdallah M.Azzeer — 3

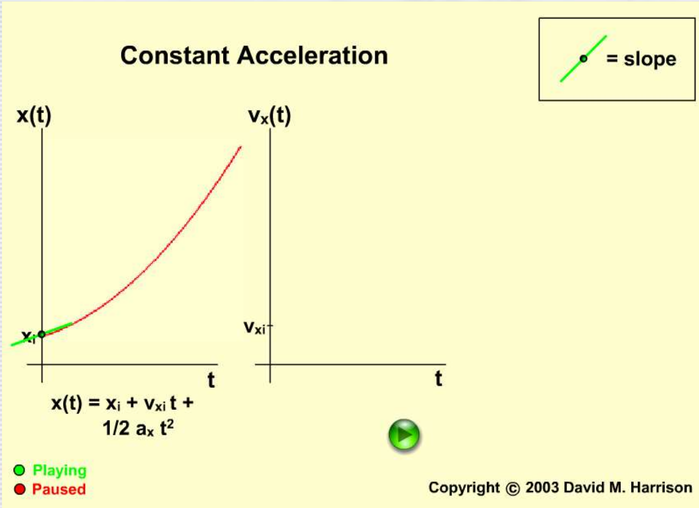
Summary; Equations of motion with constant acceleration

$$(x, v, a, t)$$

$v = v_o + at$	(v, a, t)	without the "x"
$x - x_o = v_o t + \frac{1}{2} a t^2$	(x, a, t)	without the "v"
$x - x_o = \frac{1}{2}(v + v_o)t$	(x, v, t)	without the "a"
$v^2 = v_o^2 + 2a(x - x_o)$	(x, v, a)	without the "t"

Sign convention for quantity "x", "v" and "a" is VERY IMPORTANT!

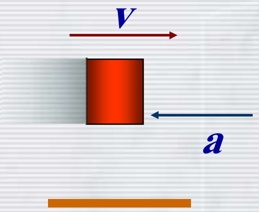
103 Phys — Dr. Abdallah M.Azzeer — 4



L:\103 Phys LECTURES SLIDES_T2Y3839\CH2Flash

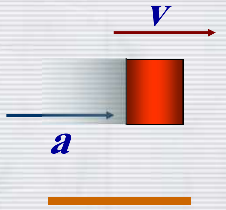
Sign convention :

$$v = v_o + (-a)\,t$$



Both "*v*" and "*a*" have opposite sign !

$$v = v_o + at$$



Both "*v*" and "*a*" have same sign !

READ EXAMPLES 2.6 to 2.8 in the Textbook

EXAMPLES

A motorist traveling at 90 km/h applied the brakes for 5 s. If the deceleration was 3 m/s², then his final speed will be:

(a) 35 m/s
(b) 25 m/s
(c) 15 m/s
(d) 10 m/s ⬅

$$v = v_o + at = \frac{90\times1000}{3600} - 3\times5 = 10\ m/s$$

A jet plane accelerates on a runway from rest at 4 m/s2, the distance and the velocity of the jet after 5 sec is:

(a) 30 m, 20 m/s
(b) 40 m, 10 m/s
(c) 50 m, 20 m/s ⬅
(d) 100 m, 10 m/s

$$x = v_o t + \frac{1}{2}at^2 = 50\ m$$

$$v = v_o + at = 20\ m/s$$

A car travels north at 40 m/s for 1 h. It stops for 50 minutes and return south traveling 10 km for 20 minutes. Its average velocity and speed respectively are:

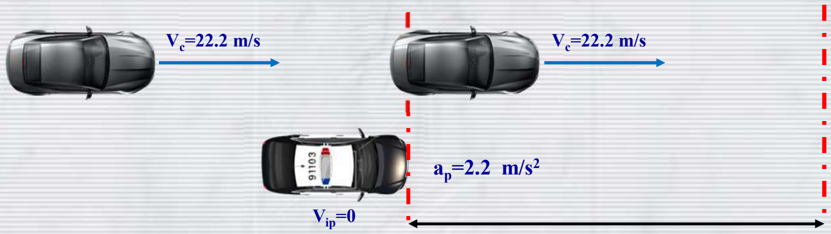
(a) 10.5, 10 m/s
(b) 12.1, 12.5 m/s
(c) 17.2, 19.7 m/s ⬅
(d) 14.2, 16 m/s

Displacement=40×3600-10000=134000 m
Distant=40×3600+10000=154000 m
Total time=3600+50×60+20×60=7800 sec
Av. Velocity=134000/7800=17.2 m/s
Av. Speed =154000/7800=19.7 m/s

A car is traveling 22.2 m/s in a school zone. A police car starts from rest just as the speeder car passes it and accelerates at a constant rate of 2.2 m/s².

(a) When does the police car catch the speeder car?

(b) How fast the police car traveling when it catches the speeder?



V_c= constant=22.2 m/s ➡ $a_c=0$, $V_{ip}=0$

(a) Since the car is traveling with constant velocity, its position x_c is given by , with $a_c = 0$: $x_c = v_o t + \frac{1}{2}a_c t^2$ ➡ $x_c = v_o t = 22.2\,t$

The position of the police car x_p, is given by $x_p = \frac{1}{2}at^2 = \frac{1}{2}(2.2)\,t^2$

We find the time when the two cars are at the same position by setting $x_c = x_p$ and solving for t: $(22.2)\,t = \frac{1}{2}(2.2)\,t^2$

t = 20 s

The police car thus catches the speeder at time $t = 20\,s$ from his startup

(b) The velocity of the police car is given by $v = v_o + at$, with $v_0 = 0$:

$$v_p = at = (2.2)\,t$$

At t = 20 s, the velocity of the police car is;

$$v_p = (2.2)(20\text{ s}) = 44\text{ m/s} = 158.4\text{ km/h}$$

At this time, the speed of the police car is twice that of the speeder. This must be true because the average velocity of the police car is half its final velocity, and since both cars cover the same distance in the same time, they must have equal average velocities.

EXAMPLES

تحتاج طائرة إلى 20 s ومدرج طوله 400 m حتى تقلع من السكون ، لذا تكون سرعتها عندما تترك عجلاتها الأرض هي

(a) 20 m/s (b) 32 m/s (c) 40 m/s (d) 80 m/s

تقطع حافلة مسافة 400 m بين نقطتي توقف .إذا بدأت من السكون وتسارعت بمقدار 1.5 m/s² حتى تصل سرعتها الى 9 m/s وبعد ذلك استمرت بنفس السرعة لفترة من الزمن ومن ثم تباطأت بمقدار 2 m/s² لكي تقف 0 أحسب الزمن الكلي الذي استغرقته الحافلة لقطع المسافة بين نقطتي التوقف .

خلال رحلة الحافلة نجد أن هناك ثلاث مراحل مبينة في الشكل السابق:

المرحلة الأولى:(I)

$v_0=0$; $a=+1.5\ m/s^2$; $v_f=9\ m/s$

$v_f=v0+at$ → $t_I=(v_f-v_0)/a=6\ s$

خلال هذا الزمن تكون الحافلة قطعت مسافة

$x_I=(v_{2f}-v_{20})/2a=27\ m$

المرحلة الثالثة:(II)

$v_0=9\ m/s$; $v_f=0$; $a=-2\ m/s2$

$t_{III}=(v_f-v_0)/a=4.5\ s$

خلال هذا الزمن تكون الحافلة قطعت مسافة

$x_{III}=(v_{2f}-v_{20})/2a=20.25\ m$

وبناء علية تكون الحافلة قد قطعت مسافة في المرحلة الثانية (II)

$x_{II}=400-(x_I+x_{III})=352.75\ m$

و حيث أن a=0 فى المرحلة الثانية (II) فإن

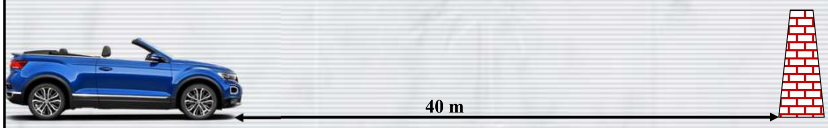
$x_{II}=v_0t_{II}$ → $t_{II}=x_{II}/v_0=39.2\ s$

الزمن الكلي للرحلة

$T=t_I+t_{II}+t_{III}=50\ s$

A driver of a car going 90 km/h suddenly sees the lights of a barrier 40m ahead. It takes the driver 0.75 seconds before he applies the brakes (this is known as the reaction time). Once he does begin to brake, he decelerates at a rate of 10.0 m/s^2.

a) Does he hit the barrier?
b) What would be the maximum speed at which the car could travel and NOT hit the barrier 40m ahead?



(a) 50 m > 40 m
(b) 14.26

الاختبار الفصلي
الفصل الدراسي الأول من العام الجامعي 1444

اليوم	التاريخ	المقرر	فترة الاختبار
الأحد	١٤٤٤/٣/١٣هـ ٢٠٢٢/١٠/٩ م	فيز ١٠٣	٧:٠٠ م الى ٩:٠٠ م

دعائنا لكم
بالتوفيق والنجاح