Homework Solutions to HW Set # 2 **due** 09 / 21 / 2003

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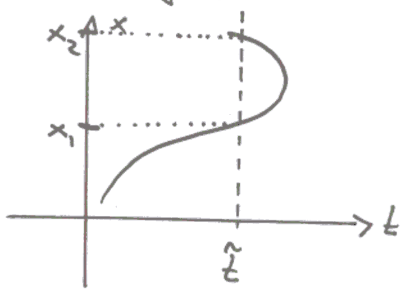
On 09 / 03 / 2003

QQ 2.4

Answer: Graph b) is physically impossible

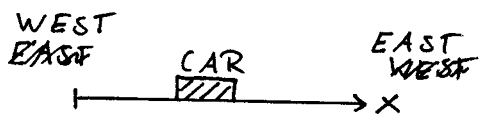


According to graph b), there are some instants in time when the object is simultaneously at two different x-coordinates. For example for $t=\tilde{t}$ the object is at x_1 and at x_2. This is physically impossible.

CQ 7:

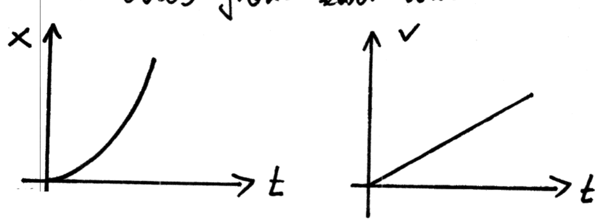
The acceleration of both objects is the same and constant in time. The gravity acts on the both objects independantly of there velocity.

CQ 14:



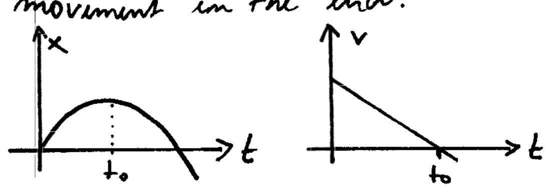
a) V = pos. ; a = pos.

Car moves from ~~east~~ west to east and it gets faster



b) V = pos. ; a = neg.

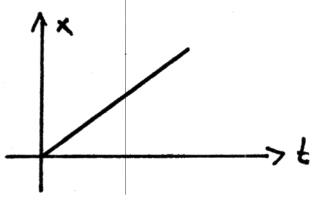
Car goes from west to east but it gets slower and changes the direction of movement in the end.

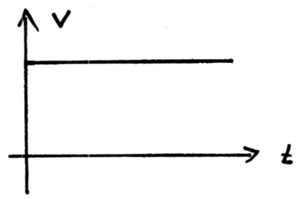


to CQ14:

$V = \text{pos.}$; $a = 0$

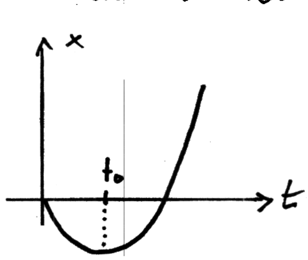
Car moves with constant velocity from west to east.

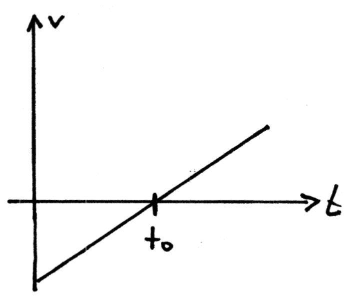




$V = \text{neg.}$, $a = \text{pos.}$

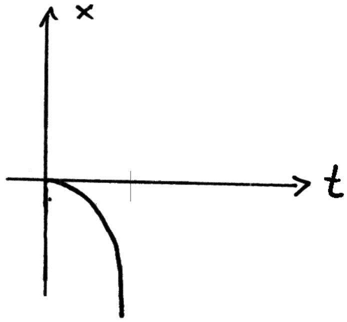
Same case as b) but now with different signs for velocity and acceleration so that the movement goes now in the other direction.

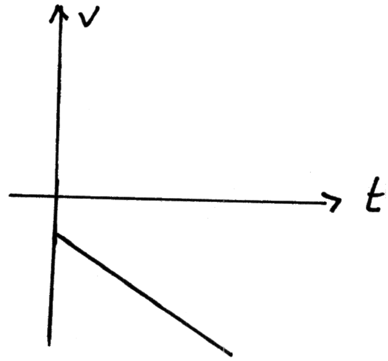




$V = \text{neg.}$, $a = \text{neg.}$

Same as a) but now the car moves from east to west.





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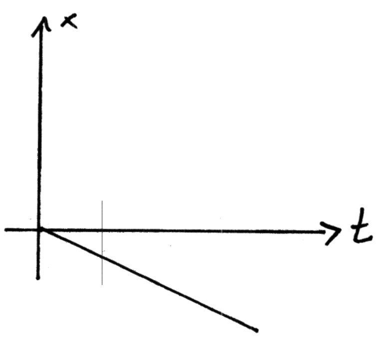
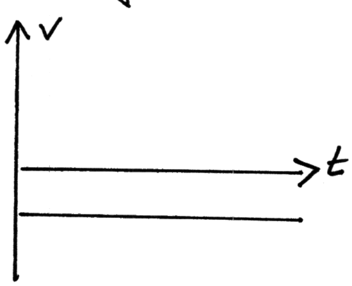
to CQ 14

d) $v =$ neg. $\quad a = 0.$

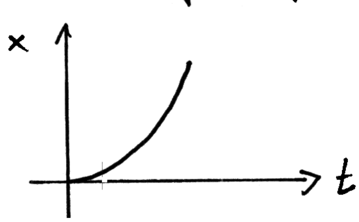
Same as c) but now car goes from east to west.

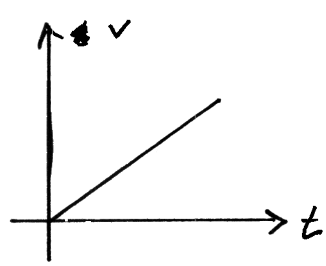




g) $v = 0$; $a =$ pos.

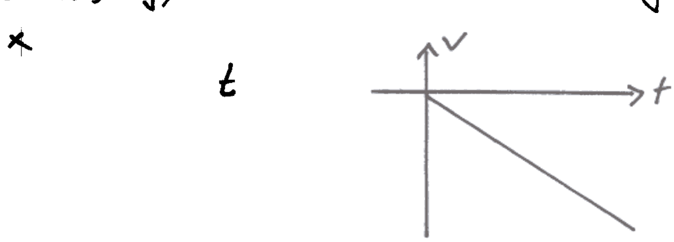
In the beginning car is in rest but through the positive acceleration it begins immediately to move from ~~east to west~~ west to east and it gets faster.





h) $v = 0$, $a =$ neg.

same as g) but now car moves from east to west



P 8

a) car I: $V_I = 55 \frac{mi}{h}$

car II: $V_{II} = 70 \frac{mi}{h}$

$x = 10\,mi$, t to be determined

$$v = \frac{x}{t} \Leftrightarrow v \cdot t = x \Leftrightarrow \underline{\underline{t = \frac{x}{v}}}$$

$t = ?$ for car I $\quad t_I = \frac{x}{V_I} = \frac{10\,mi}{55\,mi/h} = 0.1818\,h$

for car II $\quad t_{II} = \frac{x}{V_{II}} = \frac{10\,mi}{70\,mi/h} = 0.1429\,h$

$$\Delta t = t_I - t_{II} = 0.0389\,h = 2.34\,min$$

$\Rightarrow$ Car II arrives $\underline{\underline{\Delta t = 2.34\,min}}$ before car I.

b) $\Delta t = 15\,min$; x has to be determined.

$$\Delta t = t_I - t_{II} = \frac{x}{V_I} - \frac{x}{V_{II}} = \frac{V_{II}x - V_I x}{V_I V_{II}}$$

$$\Leftrightarrow \Delta t \,(V_I V_{II}) = x\,(V_{II} - V_I)$$

$$\Leftrightarrow x = \Delta t \frac{V_I V_{II}}{(V_{II} - V_I)}$$

$$x = 0.25\,h \frac{(70 \times 55)\,\frac{mi^2}{h^2}}{(70 - 55)\,\frac{mi}{h}} = \underline{\underline{64.17\,mi}}$$

[Since the lead of car II ~~shows~~ has a linear relation with the time, you can get the same result by using the result from a): $10\,mi \times \left(\frac{15\,min}{2.34\,min}\right) = 64.11\,mi$]

P 13:

$\bar{v} = 250 \frac{km}{h}$ ($\bar{v} :=$ average speed).

$x = 1600\ m$

$\frac{x}{t} \iff \boxed{t = \frac{x}{v}}$

$$t = \frac{1.600\,km}{250\,km/h} = \frac{1.6}{250} \times 3600\ s = 23.04\ s$$

For achieving an average speed of $\frac{250\,km}{h}$ the car has to make the track in 23.04 s

For the first 800 m the car goes just with $v_I = 230\ km/h$

$$\Rightarrow t_I = \frac{800\,m}{(230/3.6)\,\frac{m}{s}} = 12.52\ s$$

$\Rightarrow$ The car has just $t_{II} = t - t_I = (23.04 - 12.52)\,s = 10.52\,s$ left for the 2^{nd} 800 m.

$$V_{II} = \frac{800\,m}{\cdot} = \frac{800}{10.52}\ \frac{m}{s} = \frac{800}{10.52} \times 3.6\ \frac{km}{h}$$

$$= \underline{\underline{273.76\ \frac{km}{h}}}$$

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P21.

$$\boxed{\Delta V = a \cdot t} \iff t = \frac{\Delta V}{a}$$

t: to be determined

$$a = 0.60 \frac{m}{s^2} = 0.60 \frac{1}{1609} \frac{mi}{s^2}$$

$$\Delta V = V_{II} - V_{I} = 5 \frac{mi}{h} = \frac{5}{3600} \frac{mi}{s}$$

$$t = \frac{\Delta V}{a} = \frac{5/3600 \frac{mi}{s}}{0.6/1609 \frac{mi}{s^2}} = \underline{\underline{3.725\,s}}$$

P29:

$$\boxed{\Delta V = a \cdot t} \qquad \boxed{x = \frac{1}{2} a t^2}$$

a) $x = 240\,m$; $V = 120 \frac{km}{h} = 33\frac{1}{3} \frac{m}{s}$, a : to be determined

$$\frac{1}{2} a t^2 = \frac{1}{2} \frac{(at)^2}{a} = \frac{1}{2} \frac{(\Delta V)^2}{a}$$

$$\iff a = \frac{(\Delta V)^2}{2x}$$

$$a = \frac{(33\frac{1}{3} \frac{m}{s})^2}{2 \times 240 m} = \underline{\underline{2.315 \frac{m}{s^2}}}$$

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P38 :

• The whole train has to pass the crossing.

$\Rightarrow x = 400\,m = 0.4\,km$

Initial speed $v_1 = 82.4\,km/h$

Speed after passing the crossing $v_2 = 16.4\,km/h$ $\Big\}\ \Delta v = v_2 - v_1 = -66\,km/h$

t : to be determined.

$$\boxed{\Delta v = a \cdot t} \qquad \boxed{x = v_1 t + \frac{1}{2} a t^2}$$

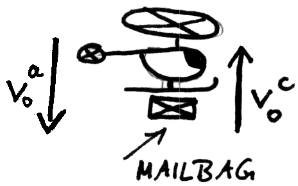
$$\Rightarrow \quad x = v_1 t + \frac{1}{2} \Delta v\, t = t\left(v_1 + \frac{1}{2}\Delta v\right)$$

$$\Leftrightarrow \quad t = \frac{x}{v_1 + \frac{1}{2}\Delta v}$$

$$t = \frac{0.4\,km}{(82.4 - \frac{1}{2}66)\,km/h} = \frac{0.4}{} \times 3600\,s$$

$$= 29.15\,s$$

P47:



(here: velocity defined as positive for descending).

- In the beginning helicopter and mailbag have the same velocity.
- Then mailbag is accelerated through the force of gravity while helicopter keeps V_0.

a) $\boxed{V = V_0 + a \cdot t}$, $V_0^a = 1.5\ \frac{m}{s}$; $a = g = 9.80\ \frac{m}{s^2}$; $t = 2s$

V: to be determined.

$$V = 1.5\ \frac{m}{s} + 9.80\ \frac{m}{s^2} \times 2s = \underline{\underline{21.1\ \frac{m}{s}}}$$

b) $\boxed{x = \frac{1}{2} a t^2}$ $a = 9.80\ \frac{m}{s^2}$; $t = 2s$;

$x = \frac{1}{2}\ 9.80\ \frac{m}{s^2} \cdot 4 s^2 = 19.6\ m$ (both, the helicopter and the mailbag are moving downward).

Mailbag is 19.6 m below helicopter.

c) V_0 has now different sign. $V_0^a = 1.5\ \frac{m}{s} \leftrightarrow V_0^c = -1.5\ \frac{m}{s}$

$\Rightarrow$ in a) $V = -1.5\ \frac{m}{s} + 9.80\ \frac{m}{s^2} \cdot 2s = \underline{\underline{18.1\ \frac{m}{s}}}$

in b) $x = \frac{1}{2} \times 9.80\ \frac{m}{s^2} \times 4s^2 = \underline{\underline{19.6m}}$ (both, the helicopter and the mailbag are moving upward).

(NO CHANGES TO b)).

P58:

t_{reac} to be defined

$x = 200\,ft$; $a = -9.00\,ft/s^2$, $v_0 = 35\,\frac{mi}{h} = 1.47 \times 35\,\frac{ft}{s}$

$\boxed{x = t \cdot v_0 + \frac{1}{2} a (t - t_{rec})^2}$ $\boxed{a \cdot (t - t_{rec}) = -v_0}$

$$x = t \cdot v_0 + \frac{1}{2} \frac{a^2 (t - t_{reac})^2}{a}$$

$$x = t \cdot v_0 + \frac{1}{2} \frac{(-v_0)^2}{a}$$

$$\Leftrightarrow \quad x - \frac{1}{2} \frac{v_0^2}{a} = t \cdot v_0$$

$$\Leftrightarrow \quad t = \frac{x - \frac{1}{2}\frac{v_0^2}{a}}{v_0}$$

$$\frac{200\,ft - \frac{1}{2} \frac{(1.47 \times 35)^2\,\frac{ft^2}{s^2}}{-9.00\,ft/s^2}}{1.47 \times 35\,ft/s} = 6.746\,s$$

$$a \cdot (t - t_{reac}) = -v_0$$

$$\Leftrightarrow \quad -\frac{v_0}{a} = t - t_{reac}$$

$$\Leftrightarrow \quad -\frac{v_0}{a} - t = -t_{reac}$$

$$\Leftrightarrow \quad \frac{v_0}{a} + t = t_{reac}$$

$$\frac{1.47 \times 35\,\frac{ft}{s}}{-9.00\,ft/s^2} + 6.746\,s = \underline{\underline{1.029\,s = t_{reac}}}$$