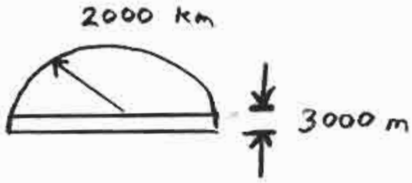
PHYSICS 131

WINTER 2005

HOMEWORK SET 1 SOLUTIONS

1.7)



The volume of Antarctica is

$$V = (\text{area of semicircle}) \cdot (\text{thickness})$$

First convert the radius to m:

$$2000 \text{ km} \cdot \frac{1000 \text{ m}}{1 \text{ km}} = 2 \times 10^6 \text{ m}$$

$$\text{area of semicircle} = \frac{1}{2}(\pi \cdot \text{radius}^2)$$

$$= \frac{1}{2}\left(\pi \left(2 \times 10^6 \text{ m}\right)^2\right) = 6.283 \times 10^{12} \text{ m}^2$$

So $V = (6.283 \times 10^{12} \text{ m}^2) \cdot (3000 \text{ m}) = 1.88 \times 10^{16} \text{ m}^3$

Finally, convert to cm^3:

$$1.88 \times 10^{16} \text{ m}^3 \cdot \frac{100 \text{ cm}}{1 \text{ m}} \cdot \frac{100 \text{ cm}}{1 \text{ m}} \cdot \frac{100 \text{ cm}}{1 \text{ m}} = 1.88 \times 10^{22} \text{ cm}^3$$

1.10) a) 1 microcentury (= 1 μcentury)

$$1 \, \mu\text{century} \cdot \frac{\text{century}}{10^6 \, \mu\text{century}} \cdot \frac{100 \text{ y}}{1 \text{ century}} \cdot \frac{365.25 \text{ d}}{1 \text{ y}} \cdot \frac{24 \text{ h}}{1 \text{ d}} \cdot \frac{60 \text{ min}}{1 \text{ h}}$$

$$= 52.6 \text{ min}$$

b) So the actual value of a μcentury is 52.6 min and Fermi's approximation is 50 min.

So actual = 52.6 min

approximation = 50 min

$$\% \text{ difference} = \left(\frac{\text{actual} - \text{approximation}}{\text{actual}}\right) 100$$

$$= \left(\frac{52.6 - 50}{52.6}\right) 100 = 4.9$$

1.21) a) Need to convert $1\ m^3\ H_2O$ to kg

The density of H_2O is $\frac{1 g}{cm^3}$.

$$1\ m^3\ H_2O \cdot \frac{100\ cm\ H_2O}{1\ m\ H_2O} \cdot \frac{100\ cm\ H_2O}{1\ m\ H_2O} \cdot \frac{100\ cm\ H_2O}{1\ m\ H_2O} = 1 \times 10^6\ cm^3\ H_2O$$

Now $1 \times 10^6\ cm^3\ H_2O \cdot \frac{1 g\ H_2O}{cm^3\ H_2O} = 1 \times 10^6 g\ H_2O$

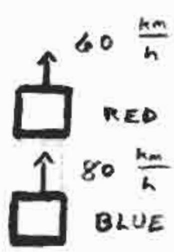
$$1 \times 10^6 g\ H_2O \cdot \frac{kg\ H_2O}{1000 g\ H_2O} = 1000\ kg\ H_2O$$

b) Need to convert $\frac{5700\ m^3}{10.0\ h}$ to $\frac{kg}{s}$.

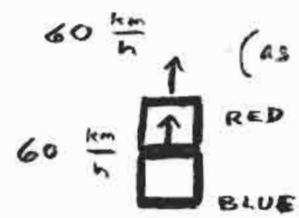
From part a, the conversion factor $\frac{1000\ kg\ H_2O}{1\ m^3\ H_2O}$ can be used

So $\frac{5700\ m^3\ H_2O}{10.0\ h} \cdot \frac{1000\ kg\ H_2O}{1\ m^3\ H_2O} \cdot \frac{1\ h}{60\ min} \cdot \frac{1\ min}{60\ s} = 158\ \frac{kg}{s}$

2.Q3) The Chihuahua moves at constant speed for time periods during which its acceleration is zero. From the graph, the only time period for which acceleration is zero is time period E.

2.Q6) 

(originally)



(as the two cars meet)

As the blue car just meets the red car, the maximum speed it can have is 60 $\frac{km}{h}$. At this speed, the blue & red cars will move together at 60 $\frac{km}{h}$. If the blue car is going any faster than 60 $\frac{km}{h}$ when it reaches the red car, the two cars will collide.

2.3) a) $V_{avg} = \dfrac{x_2 - x_1}{t_2 - t_1} = \dfrac{\Delta x}{\Delta t}$

Call the first 40 km be "leg a", the second 40 km "leg b."

So $\Delta t = \Delta t_a + \Delta t_b$

Δt_a & Δt_b aren't given, but can be found:

$\Delta x_a = V_{x_a} \Delta t_a$ where $\Delta x_a = 40$ km, $V_{x_a} = 30 \frac{km}{h}$.

$40\ km = 30 \frac{km}{h} \cdot \Delta t_a$

$\Delta t_a = \frac{4}{3} h$

Similarly, $\Delta x_b = v_{x_b} \Delta t_b$ where $\Delta x_b = 40$ km, $v_{xb} = 60 \frac{km}{h}$

$$40 \text{ km} = 60 \frac{km}{h} \cdot \Delta t_b$$

$$\Delta t_b = \frac{2}{3} h$$

So $\Delta t = \frac{4}{3} h + \frac{2}{3} h = \frac{6}{3} h = 2 h$

$$\Delta x = \Delta x_a + \Delta x_b = 40 \text{ km} + 40 \text{ km} = 80 \text{ km}$$

So $v_{avg} = \frac{\Delta x}{\Delta t} = \frac{80 \text{ km}}{2 \text{ h}} = 40 \frac{km}{h}$

($+ 40 \frac{km}{h}$: in the positive x-direction)

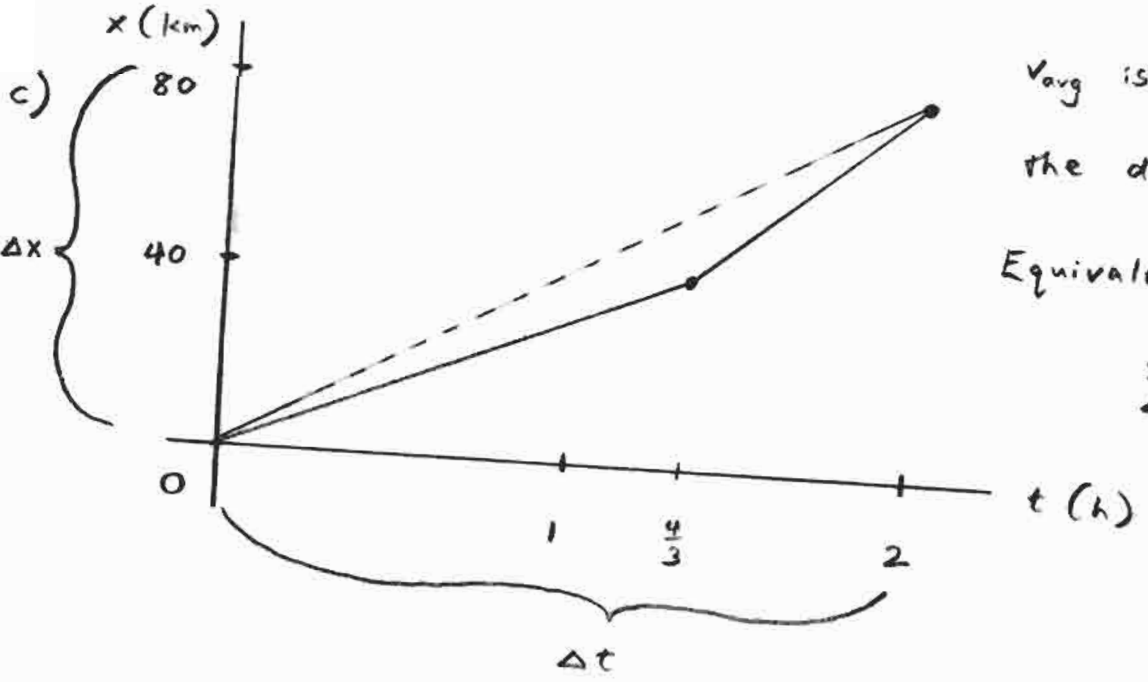
b) $s_{avg} = \frac{\text{total displacement}}{\Delta t}$

Since the car travels entirely in one direction, the total displacement here is just $\Delta x = 80$ km.

Δt is the same.

So $s_{avg} = \frac{80 \text{ km}}{2 \text{ h}} = 40 \frac{km}{h}$

c)

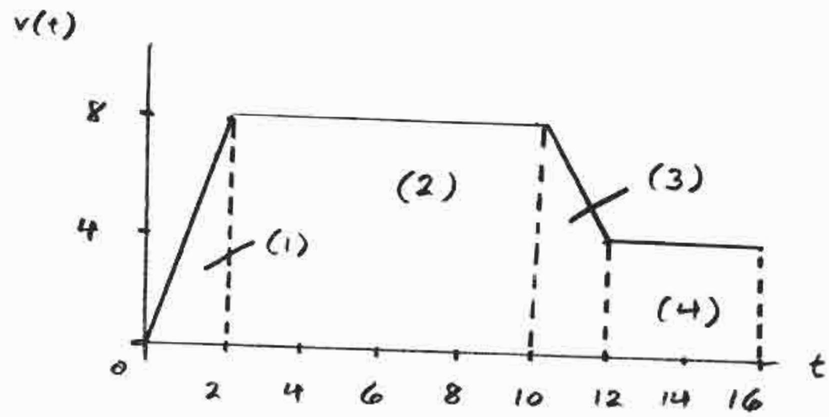


v_{avg} is the slope of the dashed line.

Equivalently, it is

$$\frac{\Delta x}{\Delta t} = \frac{80}{2} = 40 \frac{k}{h}$$

2.13) The distance traveled by an object whose velocity-time graph is given is the area under the graph.



$$\text{area} = (1) + (2) + (3) + (4)$$

$$= \tfrac{1}{2}(2)(8) + (8)(8) + \tfrac{1}{2}(2)(4) + (2)(4) + (4)(4)$$

$$= 100 \text{ m}$$

2.17) $$a_{avg} = \frac{v_2 - v_1}{t_2 - t_1} = \frac{\Delta v}{\Delta t}$$

v_1 = particle's velocity initially

v_2 = particle's velocity 2.4s later

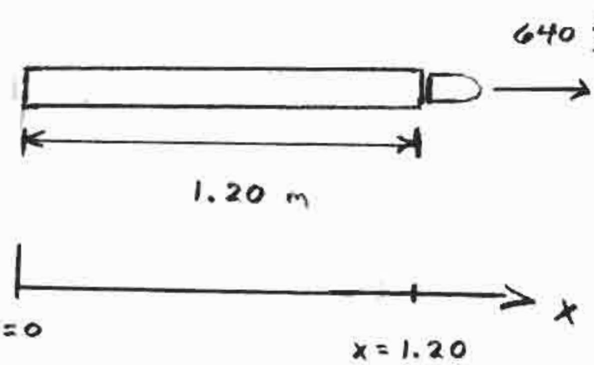
Let the positive x-direction be in the direction of the particle's initial motion. Then, since the particle is going in the opposite direction 2.4s later, its velocity 2.4s later is in the negative x-direction. So

$v_1 = 18 \frac{m}{s}$, $v_2 = -30 \frac{m}{s}$. Also $\Delta t = 2.4s$.

So $a_{avg} = \frac{v_2 - v_1}{t_2 - t_1} = \frac{-30-(18)}{2.4} = -20 \frac{m}{s^2}$

So the magnitude of the average acceleration is $20 \frac{m}{s^2}$, & the minus sign says that its direction is in the negative x-direction — in the direction of the $30 \frac{m}{s}$ movement.

2.26)



The bullet starts at $x=0$; assume $x_0 = 0$.

$v_0 = 0$ since bullets are stationary when they are fired.

The end of the bullet's trip that is being considered is at the end of the barrel:

$x = 1.20$ and $v = 640$

First find the bullet's acceleration in the barrel:

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

$$640^2 = 0^2 + 2a(1.20 - 0)$$

$$a = 1.71 \times 10^5 \frac{m}{s^2}$$

Now find the time the bullet spent travelling down the barrel:

$$x - x_0 = v_0 t + \frac{1}{2} a t^2$$

$$1.20 - 0 = 0(t) + \frac{1}{2}(1.71 \times 10^5) t^2$$

$$1.20 = (8.53 \times 10^4) t^2$$

$$t = 3.76 \times 10^{-3} \text{ s}$$

2.33) a) First convert $56.0 \frac{km}{h}$ to $\frac{m}{s}$:

$$56.0 \frac{km}{h} \cdot \frac{1000 \text{ m}}{1 \text{ km}} \cdot \frac{1 \text{ h}}{60 \text{ min}} \cdot \frac{1 \text{ min}}{60 \text{ s}} = 15.6 \frac{m}{s}$$

so $V_0 = 15.6 \frac{m}{s}$, $x - x_0 = 24.0 \text{ m}$, $t = 2.00 \text{ s}$

$$x - x_0 = v_0 t + \frac{1}{2} a t^2$$

$$24.0 = 15.6(2.00) + \frac{1}{2} a (2.00)^2$$

$$a = -3.6 \frac{m}{s^2}$$

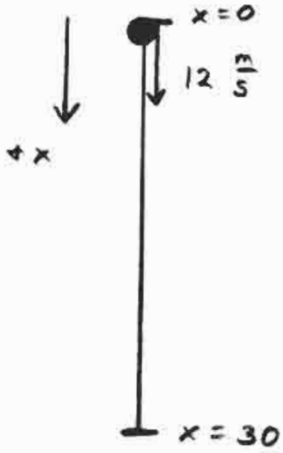
b) now $V = V_0 + at$

$$v = 15.6 + (-3.6)(2.00)$$

$$v = 8.4 \frac{m}{s}$$

2.42)

a)



Let the positive x-direction be downward.

$x - x_0 = 30\,m$

$v_0 = 12\ \frac{m}{s}$

$a = 9.8\ \frac{m}{s^2}$

$x - x_0 = v_0 t + \frac{1}{2} a t^2$

$30 = 12t + \frac{1}{2}(9.8)t^2$

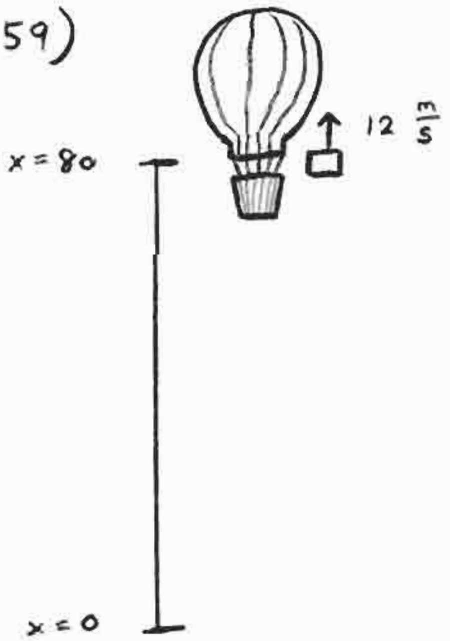
Solving this quadratic equation gives $t = 1.5\,s$.

b) $v = v_0 + at$

$v = 12 + (9.8)(1.5)$

$v = 27\ \frac{m}{s}$

2.59)



a) Since the balloon is moving at $12\ \frac{m}{s}$, so is the package (initially).

$x = 0,\ x_0 = 80,\ v_0 = 12,\ a = -9.8$

$x - x_0 = v_0 t + \frac{1}{2} a t^2$

$0 - 80 = 12t + \frac{1}{2}(-9.8)t^2$

$-80 = 12t - 4.9t^2$

Solving this equation yields

$t = 5.4\ s$

b) $v = v_0 + at$

$v = 12 + (-9.8)(5.4)$

$v = -41\ \frac{m}{s}$

the velocity is $-41\ \frac{m}{s}$, so the speed is just $41\ \frac{m}{s}$