Physics 218-F2006
Mid term 1

Name: _ Blue
Section #: ______

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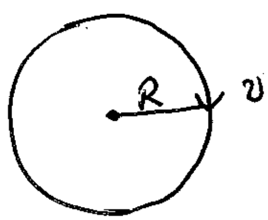
$g=9.8\ m/s^2$	$v=v_0+at$	$Sin(A\pm B)=SinACosB\pm CosASinB$
$v_{ave}=\Delta x/\Delta t$	$x-x_0=(v+v_0)t/2$	$Cos(A+B)=CosACosB-SinASinB$
$a_{ave}=\Delta v/\Delta t$	$v^2=v_0^2+2a(x-x_0)$	$Cos(A-B)=CosACosB+SinASinB$
$a_{rad}=v^2/R$	$x-x_0=v_0t+at^2/2$	$Cos30°=Sin60°=\sqrt{3}/2$; $Tan30°=1/\sqrt{3}$
$c=3x10^8 m/s$	$Cos^2A+Sin^2A=1$	$Cos60°=Sin30°=1/2$; $Tan60°=\sqrt{3}$
		$Cos45°=Sin45°=1/\sqrt{2}$; $tan45°=1$

1. The earth's diameter is12760 km and rotate around its axis in 24h. a) What is the velocity of an object at the equator? b) What is the radial acceleration of that object?



$v \cdot 24h = 2\pi R = (\pi \cdot 12760\times10^3)$

$v = \frac{\pi\times12760\times10^3\ m}{24\times60\times60\ s} = 463.97\ m/s$

$a_r = \frac{v^2}{R} = \left(\frac{2\pi R}{T}\right)^2 \cdot \frac{1}{R} = \frac{4\pi^2 R}{T^2}$

$= \frac{2\pi^2 \cdot 2R}{T^2} = \frac{2\pi^2\times12760\times10^3}{(24\times60\times60)^2}\ m/s^2$

$=$

$= 3.37\times10^{-2}\ m/s^2$

2. Absent minded professor has been flying his model-T and landed in city A. Tired prof. wanted to go home located in city H. Surveying the map he sees the following. City H is $140\sqrt{3}$ miles and 30° West of North from B (take as origin). City C is $100\sqrt{3}$ miles and 30° and East of North from B. City A is 180 miles and 60° West of North from C. What is the shortest distance and direction he has to fly to come home? (Draw the diagram; indicate chosen x and y directions; show the components in each direction before adding up the numbers).

$\vec{AH} = \vec{AC} + \vec{CB} + \vec{BH}$ 03

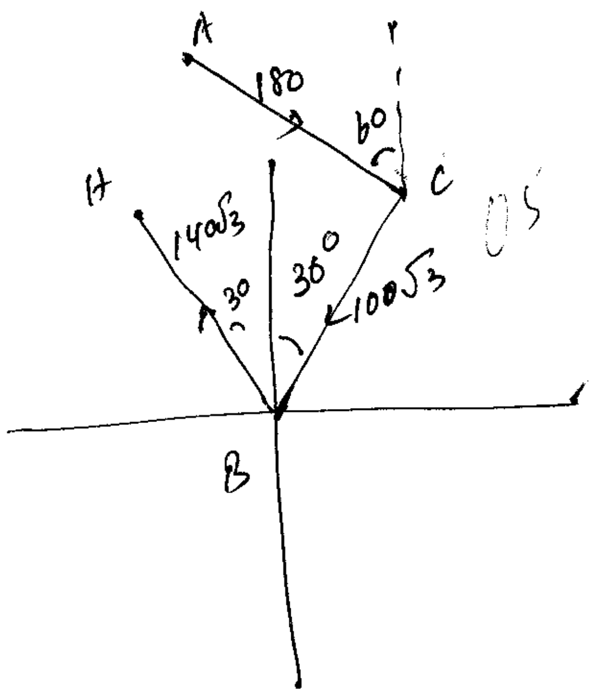
$\therefore AH_x = 180\cos 30 - 100\sqrt{3}\cos 60 - 140\sqrt{3}\cos 60$

$= 90\sqrt{3} - 120\sqrt{3} = \underline{-30\sqrt{3}}$ 04

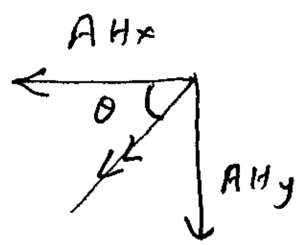
$AH_y = -180\cos 60 - 100\sqrt{3}\cos 30 + 140\sqrt{3}\cos 30$

$= -90 + 40\sqrt{3}\cos 30 = -90 + 60 = -30$

04



05

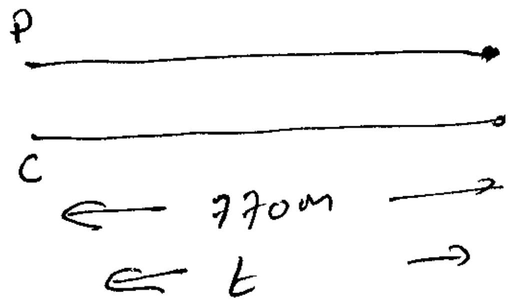


$AH = \underline{30 \times 2 \text{ miles}}$ 02

$\tan\theta = \left|\frac{AH_y}{AH_x}\right| = \frac{1}{\sqrt{3}}, \theta = 30°$ 02

direction 30° south of west

3. A police car at rest is passed by a speeder traveling at a constant speed of 110km/h. Officer takes off in pursuit and catches up with the speeder in 770m. a) How long (time) did it take the officer to overtake the speeder? b) What is his acceleration?



$x = vt$ for police car

$$\frac{110 \times 10^3}{3600} \times t = 770$$

$$\therefore t = \frac{36 \times 7}{10}$$

$$= 25.2 \text{ s}$$

for police man $\quad x = v_0 t + \frac{1}{2} a t^2$

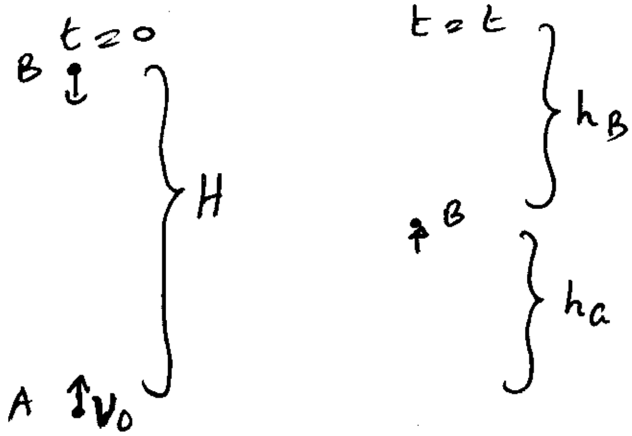
$$770 = \frac{1}{2} a \times (25.2)^2$$

$$\therefore a =$$

$$= \frac{2 \times 770}{(25.2)^2} \frac{m}{s^2}$$

$$= 2.425 \, m/s^2$$

4. A ball is dropped from a height H (with an initial velocity 0) and at the same time you shoot an arrow with an initial velocity v_0 straight up from directly below. Ignore the air resistance and assume the time taken for the arrow to hit the ball is t. a) Find the distance the ball dropped before arrow hits it? b) Find the distance arrow traveled till the collision. c) Using the above two results find the time t in terms of H,g and v_0.



Ball

$\downarrow \quad y = v_0 t + \frac{1}{2} a t^2$

$h_B = 0 + \frac{1}{2} g t^2 \quad \text{..} (1)$

arrow

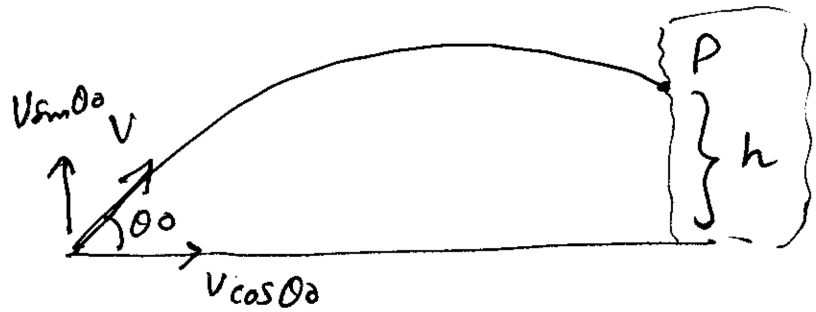
$\uparrow \quad y = v_0 t + \frac{1}{2} a t^2$

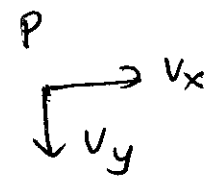
$h_a = v_0 t - \frac{1}{2} g t^2 \quad \text{..} (2)$

$(1) + (2) \Rightarrow \quad h_a + h_B = H = v_0 t$

$t = H / v_0$

5. A rocket is launched from the ground with an initial velocity v at an angle θ_0 above the horizontal. On the way down, the rocket hits a point P on a far away building. P is vertically a height h above the ground. a) Find the horizontal velocity component of the rocket just before it hits P. b) Find the vertical velocity component of the rocket just before it hits P. c) Find the velocity of the rocket just before it hits P. d) Prove that the velocity depends only on v and h.





a) ~~x – vol~~ → $V = V_0 + \overset{\to 0}{at}$

$\Rightarrow V_x = V\cos\theta_0$ (5)

b) $v^2 = V_0^2 + 2a(y - y_0)$ (5)

$V_y^2 = (V\sin\theta_0)^2 - 2gh$

$V_y = \sqrt{(V\sin\theta_0)^2 - 2gh}$ (2)

c) $V^2 = V_x^2 + V_y^2 = V^2\cos^2\theta_0 + V^2\sin^2\theta_0 - 2gh$ (5)

$= V^2 - 2gh$

d) Velocity does not have θ_0 (5)
So does not depend on θ_0

yellow

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$a_{ave}=\Delta v/\Delta t$	$v^2=v_0^2+2a(x-x_0)$	$\cos(A-B)=\cos A\cos B+\sin A\sin B$
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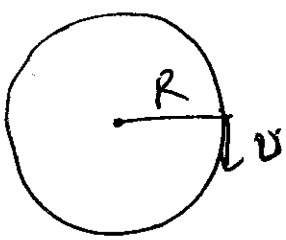
		$\cos45°=\sin45°=1/\sqrt{2}$; $\tan45°=1$

1. A Ferris wheel with a radius 14m takes 4π seconds for one rotation around a horizontal axis. a) What is the velocity of a rider? b) What is the radial acceleration of the rider?



a) $vT = 2\pi R$

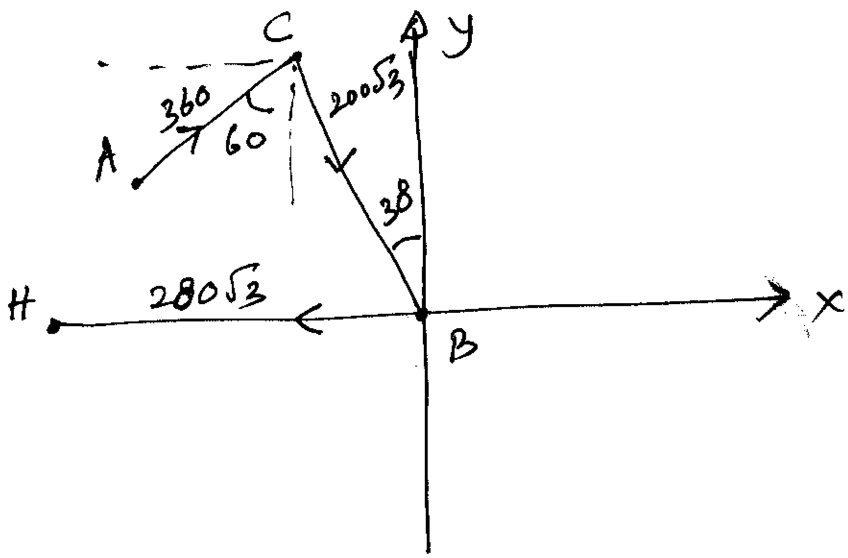
$v = \frac{2\pi R}{T} = \frac{2\pi R}{4\pi} = \frac{R}{2} = \frac{14}{2} = 7\ m/s$ (-1)

(+7) (+3)

b) $a_{rad} = \frac{v^2}{R} = \frac{R^2}{4\cdot R} = \frac{R}{4} = 3.5\ m/s^2$ (-1)

(+7) (+3)

2. Absent minded professor has been flying his model-T and landed in city A. Tired prof. wanted to go home located in city H. Surveying the map he sees the following. City H is 280√3 miles West from B (take as origin). City C is 200√3 miles and 30° West of North from B. City A is 360 miles and 60° West of South from C. What is the shortest distance and direction he has to fly to come home? (Draw the diagram; indicate chosen x and y directions; show the components in each direction before adding up the numbers).

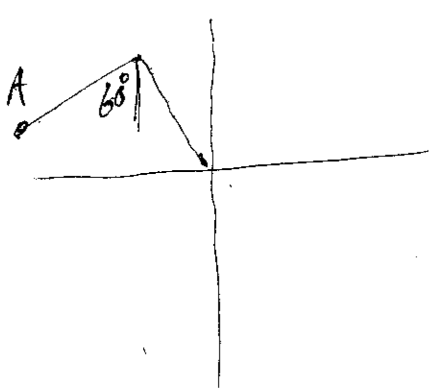


$$\vec{AH} = \vec{AC} + \vec{CB} + \vec{BH}$$

$$AH_x = 360\cos 30 + 200\sqrt{3}\cos 60 - 280\sqrt{3} = 180\sqrt{3} - 180\sqrt{3} = 0$$

$$AH_y = 360\cos 60 - 200\sqrt{3}\cos 30 = 180 - 300 = -120$$

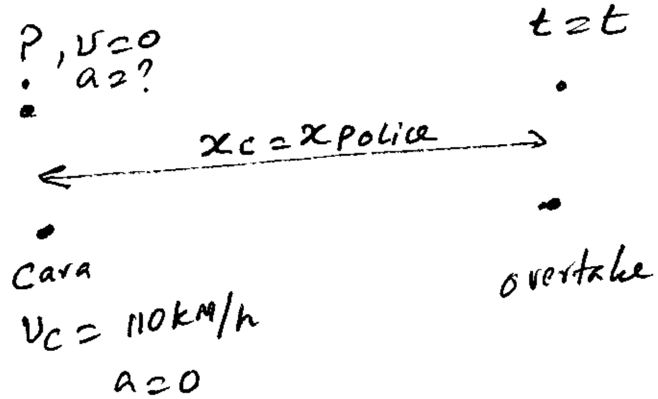
$\therefore$ $\vec{AH}$ = 120 miles to the West from A



A = (360 cos30, 360 sin30) why is this wrong

Why use velocity for distance.

3. A police car at rest is passed by a speeder traveling at a constant speed of 110km/h. Officer takes off in pursuit and catches up with the speeder in 770m. a) How long (time) did it take the officer to overtake the speeder? b) What is his acceleration?



a) $x_c = x_p = 770\,m = v_c \times t = \frac{110\,km}{h} \times \frac{10^3\,m}{km} \times \frac{h}{(3600)\,s} \cdot t$

$\therefore\ t = \frac{7 \times 3600}{1000}\,s = \underline{\underline{25.2\,s}}$

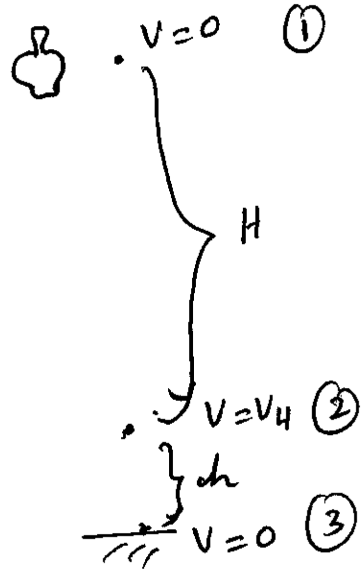
b) a_p ? $\quad v^2 = v_0^2 + 2ax\ ,\quad \underline{x = v_0 t + 1/2\, a t^2}$ ✓

$770 = \frac{1}{2} a (25.2)^2$

$\therefore\ a = \frac{2 \times 770}{(25.2)^2} \frac{m}{s^2} = \underline{\underline{2.425\,\frac{m}{s^2}}}$

4. An apple originally at rest drops freely from a tree. Apple was originally at a height H above the top of the grass tips of the lawn. Grass itself has a height h. When the apple hits the grass it slows down at a constant rate so that the speed is zero when it reaches the ground. a) What is the speed of the apple when it touches the grass? b) Find the acceleration of the apple in the grass. c) Sketch the velocity time graph for the apple

20/20



a) $V^2 = V_0^2 + 2a(y-y_0)$ ① to ②

↓ $V_H^2 = 0 + 2gH$

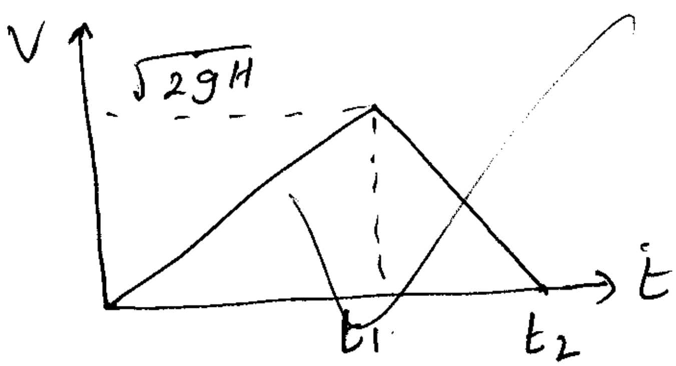
$\therefore V_H = \sqrt{2gH}$

b) again $V^2 = V_0^2 + 2a(y-y_0)$ ② to ③

↓ $0 = V_H^2 + 2a(h)$

$\therefore a = -\frac{V_H^2}{2h}$ (slowing down)

$= -gH/h$



$V = V_0 + at \Rightarrow$ ① to ②

$\sqrt{2gH} = 0 + gt_1$

$\therefore t_1 = \frac{\sqrt{2gH}}{g}$

Similarly ② to ③

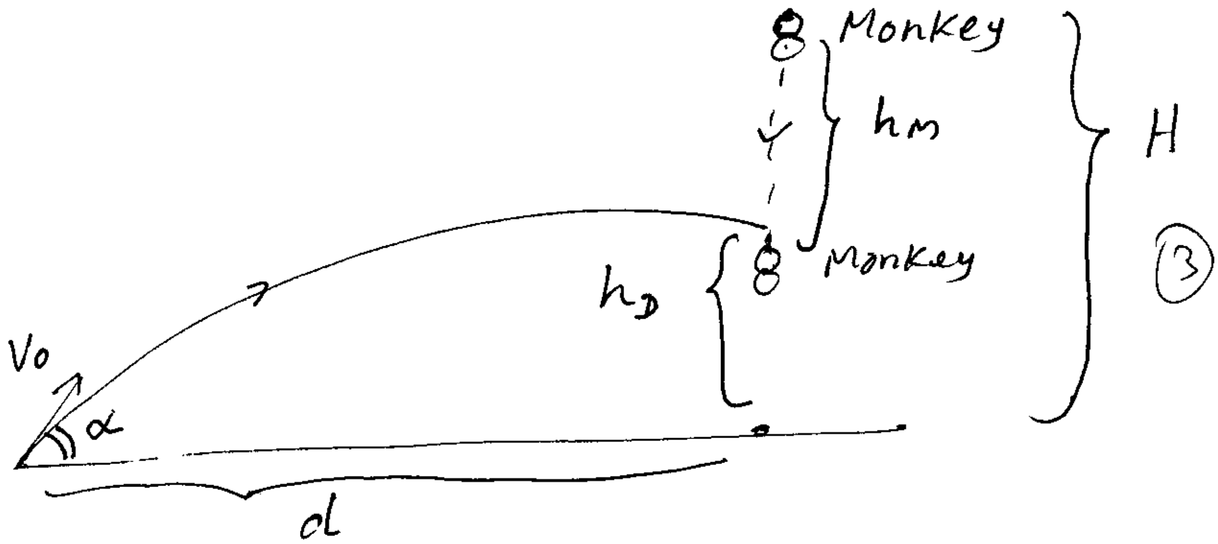
$V = V_0 + at$

$0 = \sqrt{2gH} + at_3$

$t_3 = -\frac{\sqrt{2gH}}{a} = \frac{\sqrt{2gH}}{-gH/h}$

$= \frac{2h}{\sqrt{2gH}}$

5. A monkey escaped from the zoo is hanging on a tree branch a height H above the ground. Animal catcher sitting on the ground at a horizontal distance d from the monkey aims directly at the monkey and fires a tranquilizer dart. The (clever?) monkey lets go at the same instant. Assume that the dart starts from the ground, has enough velocity (v_0) to reach monkey's path and both monkey and the dart are still above the ground when the dart reaches the path of the monkey. a) Sketch the trajectory of the dart .b) What is the vertical fall of the monkey after a time t? c) At the same time t what is the vertical height of the dart? d) What is the total vertical distance both monkey and the dart traveled? e) Does the dart hit the monkey (eliminate t, v_0 and d you will see the answer)?



b) $y = V_0 t + \frac{1}{2} a t^2$

$\downarrow \; h_m = 0 + \frac{1}{2} g t^2$ (4)

c) $\uparrow h_D = V_0 \sin\alpha \, t - \frac{1}{2} g t^2$ (4)

d) $h_D + h_m = V_0 \sin\alpha \; t$ (4)

e) $H = d \tan\alpha = V_0 \cos\alpha . t . \tan\alpha$ (5)

$= V_0 \sin\alpha \; t$

$\therefore h_D + h_m = \underline{\underline{H}}$

$\therefore$ dart hits monkey

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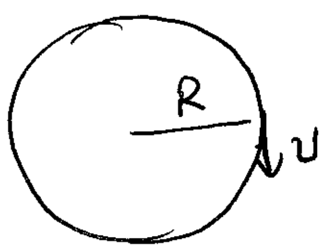
$c=3\times10^8 m/s$	$Cos^2A+Sin^2A=1$	$Cos60^\circ=Sin30^\circ=1/2$; $Tan60^\circ=\sqrt{3}$
		$Cos45^\circ=Sin45^\circ=1/\sqrt{2}$; $tan45^\circ=1$

1. The radius of the earth's orbit around the sun (assume circular) is 1.5×10^8 km, and the earth travels around the sun in 365 days. a) What is the orbital velocity of the earth (in m/s) around the sun? b) What is the radial acceleration of the earth?



a) $vT = 2\pi R$ (+1)

$v = \frac{2\pi R}{T} = \frac{2\pi \times 1.5\times10^{11}\ m}{365\times24\times3600\ s} = 2.9886\times10^4 \frac{m}{s}$ (+7) (+1) (3) (+1)

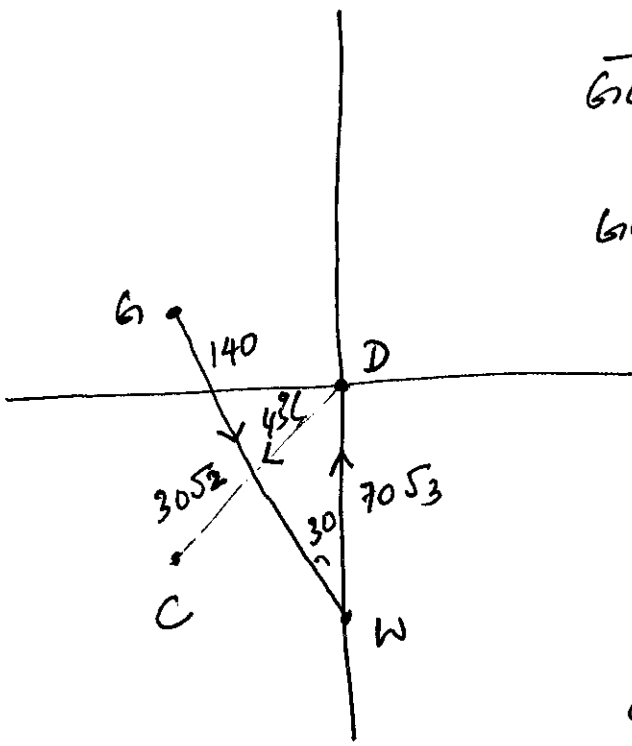
b) $a_{rad} = \frac{v^2}{R} = \frac{4\pi^2 R}{T^2} = \frac{4\pi^2 \times 1.5\times10^{11}\ m/s^2}{(365\times24\times3600)^2}$ (+7) (3)

$= 5.954\times10^{-3} \frac{m}{s^2}$ (-1)

2. Absent minded professor has been flying his model-T and landed in Graham to refuel. Tired prof. wanted to go home located in Clebune quickly. Surveying the map he sees the following. Dallas (D) is $30\sqrt{2}$ miles NE of Clebune(C). Waco is $70\sqrt{3}$ miles directly south of Dallas and Graham is 140 miles 30° West of North from Waco. What is the shortest distance and direction he has to fly to come home? (Draw a diagram with C at origin; indicate chosen x and y directions; show the components in each direction before adding up the numbers).

Need to find $\vec{GC}$

$\vec{GC} = \vec{GW} + \vec{WD} + \vec{DC}$



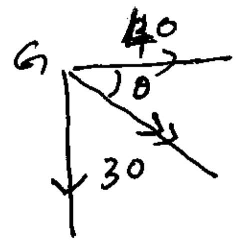
$GC_x = 140\cos 60 - 30\sqrt{2}\cos 45$

$= 70 - 30 = 40$

$GC_y = -140\cos 30 + 70\sqrt{3} - 30\sqrt{2}\cos 45$

$= -70\sqrt{3} + 70\sqrt{3} - 30$

$= -30$



$GC = 30\sqrt{2}$, $\tan\theta = \frac{GC_y}{GC_x} = -\frac{4}{3}$, $\therefore \theta = -36.9°$

Direction, South East

Graded by [illegible]

3. A car at rest at a red light is passed by a truck moving at a constant speed of 21m/s just as the light turns green. At that instant car accelerate with a constant acceleration of $3 m/s^2$. a) How long (time) did it take the car to overtake the truck? b) How far car traveled before overtaking the truck?

$v=0, a=3 m/s^2$ $t=t$

C

T →

$v_T = 21 m/s$

$t=0$

a) Overtake ⇒ $x_{car} = x_{truck}$

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

($v_0 = 0$)

$$\therefore t = \frac{2 v_T}{a} = \frac{21 \times 2}{3} = 14 \text{ secs}$$

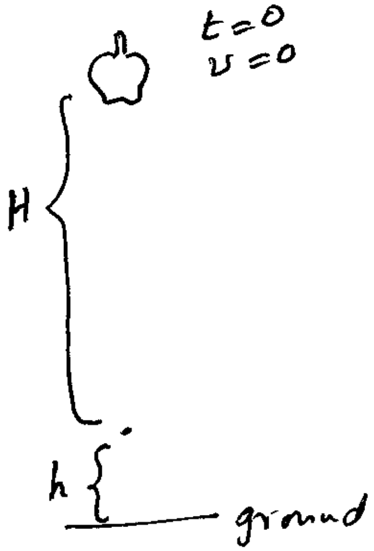
b) distance $x = v_T \cdot t = 21 \frac{m}{s} \times 14 \text{ secs}$

$$= 294$$

Graded by Teng

4. An apple originally at rest drops freely from a tree. Apple was originally at a height H above the top of the grass tips of the lawn. Grass itself has a height h. When the apple hits the grass it slows down at a constant rate so that the speed is zero when it reaches the ground. a) What is the speed of the apple when it touches the grass? b) Find the acceleration of the apple in the grass. c) Sketch the velocity time graph for the apple.

4



a) ↓ $v^2 = v_0^2 + 2a(y - y_0)$

$v_a^2 = 0 + 2gH$

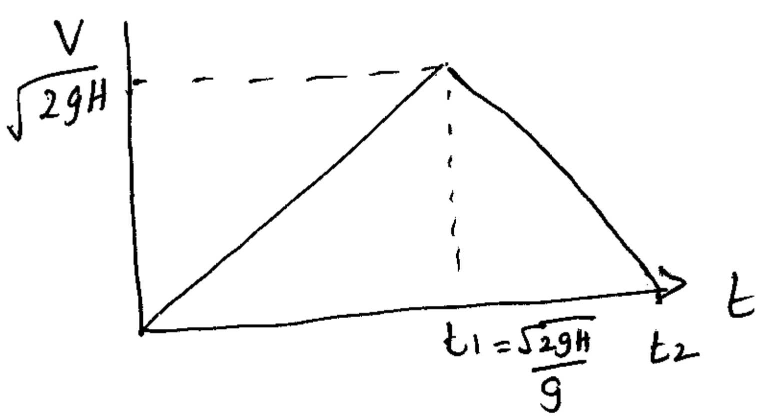
$\therefore v_a = \sqrt{2gH}$

b) again $v^2 = v_0^2 + 2a(y - y_0)$

↓ $0 = v_a^2 + 2ah$

$\therefore a = -\frac{v_a^2}{2h} = -\frac{2gH}{2h} = -g(H/h)$

−ve means slowing down.



$v = v_0 + at \Rightarrow v_a = gt_1$

$t_1 = \frac{\sqrt{2gH}}{g}$

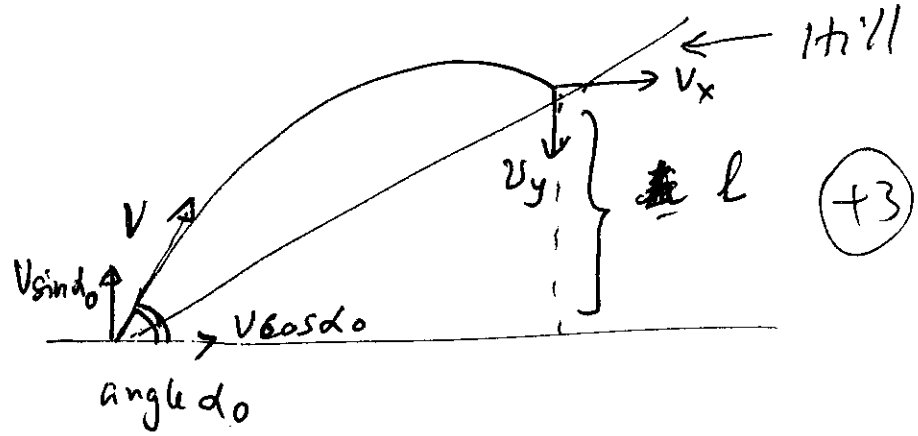
Similarly

$0 = v_a - at_2$

$t_2 = \frac{v_a}{a} = \frac{\sqrt{2gH}}{g(H/h)}$

$= \frac{2h}{\sqrt{2gH}}$

5. A hunter standing at a bottom of a hill fires his rifle at his prey grazing on the slope of the hill. Initial velocity of the bullet is v and the direction is α_0 above horizontal. The bullet on its way down, hits the prey, which is at a vertical height l form the bottom of the hill. a) Sketch the trajectory of the bullet (no calculations needed for this part). b) What is the horizontal component of the velocity of the bullet just before it hits the prey? c) Obtain the vertical component of the velocity just before it hits the prey. d) Obtain the velocity of the bullet when it hits. e) Does the velocity depend on α_0 when it hits the prey?



b) $V_x = V\cos\alpha_0$ ($V = V_0 + at$) + 4

c) ↓ $V^2 = V_0^2 + 2a(y - y_0)$

$V_y^2 = V^2\sin^2\alpha_0 + 2(g)(-l)$ (2)

$= V^2\sin^2\alpha_0 - 2gl$

$\therefore V_y = \sqrt{V^2\sin^2\alpha_0 - 2gl}$ +5

d) $V^2 = V_x^2 + V_y^2 = V^2\cos^2\alpha_0 + V^2\sin^2\alpha_0 - 2gh$

$V = \sqrt{V^2 - 2gh}$ +5 (I only need the magnitude here)

$\tan\theta = \frac{\sqrt{V^2\sin^2\alpha_0 - 2gh}}{V\cos\alpha_0}$

e) No it does not.

+3