AP Physics C – Video Lecture Notes
Chapter 01-04
Thank You, Amanda Ciccarelli, for these notes.

Video Lecture #1 – Dimensions, Conversions and Significant Figures

$2{,}500\ m^3 = ft^3$ $\quad 2500\ m^3\left(\frac{3.281\ ft}{1.000\ m}\right)^3 = 88299.59\ ft^3$

$3.281 = 1.000\ m$

$\approx 88{,}000\ ft^3$

$\Delta x = 2.56\ m$

$m = 13.1\ kg$ $\quad$ Answer = 2 sig figs

$V_{iy} = 14\ m/s$

$a_y = 17.2070\ m/s^2$

Dimensions = Friends

No naked numbers

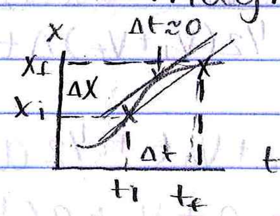
Video Lecture #2 – Introduction to Displacement, Velocity and the Derivative

Δx Displacement $\Delta \vec{x} = x_f - x_i$ vs Distance

vector $\quad$ scalar

magnitude + direction $\quad$ magnitude

Derivative: $V_x = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t}$



slope of line

$\frac{dx}{dt}$ ← derivative of x w/ respect to t

Video Lecture #3 – Introductory Examples of Derivatives including Instantaneous Velocity & Acceleration

$x(t) = t^2 \quad \frac{dx}{dt} = \frac{d}{dt}(t^2) = 2t^{2-1} = 2t = \frac{dx}{dt}$

$\frac{d}{dt} t^N = Nt^{(N-1)}$

$x = 4t^3 \quad \frac{dx}{dt} = 4(3)t^2 = 12t^2$

$y = t^4 - 3t^2 + 4 \quad \frac{dy}{dt} = 4t^3 - 6t$

$y = 17z - 2z^3 - 7z + 4$

$\frac{dy}{dz}(10z - 2z^3 + 4) = 10 - 6z^2$

$v = 4x^2 + 2x^4$

$\frac{dv}{dx} = 8x + 8x^3$

x = position Δx = displacement

$V_{avg} = \frac{\Delta x}{\Delta t}$ $V_{inst} = \frac{dx}{dt}$ instantaneous velocity

$a_{avg} = \frac{\Delta v}{\Delta t}$ $a_{inst} = \frac{dv}{dt}$

Video Lecture #4 – Using the Derivative to derive two Uniformly Accelerated Motion Equations

3 UAM Equations $a = \#$

$v_f = v_i + a\Delta t$

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

$v_f^2 = v_i^2 + 2a\Delta x$ $v_f = 0$

$\Delta x = \frac{1}{2}(v_i + v_f)\Delta t$

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

$\frac{dx}{dt} = 0 + v_0 + 2(\frac{1}{2} a t)$ $v = v_0 + at$

Video Lecture #5 – Introductory Example Problem: Position, Velocity and Acceleration using the Derivative

EX $x(t) = (3.00t^2 - 5.00t - 2.00)$ m

a) $x_i = ?$ $(t=0)$ $3(0)^2 - 5(0) - 2 = -2.00$ m

b) $v(t) = ?$ $dx/dt = 6t - 5$ $v(t) = (6.00t - 5.00)$ m

c) $a(t) = ?$ $dv/dt = 6.00$ m/s^2 UAM

d) x @ 2.00 s $x(2) = 3(2)^2 - 5(2) - 2 = 0$ m

e) v @ 2.00 s $v(2) = 6(2) - 5 = 7.00$ m/s

f) a @ 2.00 s $a(2) = 6.00$ m/s^2

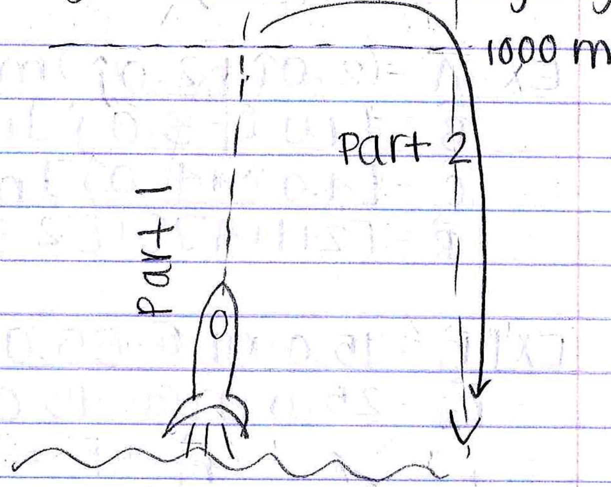
EX $x(t) = (7.00t^3 - 4.00)$ m

$\frac{dx}{dt} = 21t^2 = v(t)$ $\frac{dv}{dt} = (42.0t) = a(t)$ ~~UAM~~

Free Fall

only force acting on object is gravity

$a_y = -9.8\ m/s^2 = -g \quad g = +9.8\ m/s^2$ (3 sig figs)



EX 2-62

$v_i = 80.0\ m/s$

$y_i = 0 \quad y_f = 1000 m$

$a_1 = 4.00\ m/s^2$

$a_2 = -9.80\ m/s^2$

a) $\Delta t_t = ?$

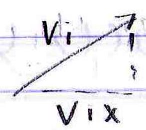
b) $h_{max} = ?$

c) $V_{2f} = ?$

a) $\Delta y_1 = v_{1i}\Delta t_1 + \frac{1}{2} a_1 \Delta t_1^2$

$1000 = 80\Delta t_1 + \frac{1}{2}(4)(\Delta t)^2$

$v_i = 35\ m/s$ @ 25° above horiz



$\sin\theta = \frac{O}{H} = \frac{V_{iy}}{V_i} \quad 35\sin 25 = 14.792 \approx 15$

$\cos\theta = \frac{A}{H} = \frac{V_{ix}}{V_i} \quad 35\cos 25 = 32\ m/s$

$v_{ix} + v_{iy}$ are components of v_i

$v_i = [32\hat{i} + 15\hat{j}]\ m/s$ unit vector (1)

EX $\vec{A} = (2.0\hat{i} + 2.0\hat{j})\,m \quad \vec{A} + \vec{B} + \vec{C} = \vec{R}$

$\vec{B} = [1.0\hat{i} - 3.0\hat{j}]\,m$

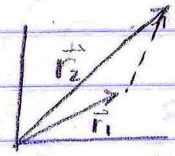
$\vec{C} = [4.0\hat{i} + 4.0\hat{j}]\,m$

$\vec{R} = [2+1+4]\hat{i} + [2-3+4]\hat{j} = [7.0\hat{i} + 3.0\hat{j}]\,m$

Video Lecture #8 – An Introductory Vector Addition Problem using Unit Vectors

EX| $\vec{r}_1 = 15.0\ m$ @ 55.0 E of N

$\vec{r}_2 = 25.0\ m$ @ 45.0° N of E



~~$\vec{r}_1 + \vec{r}_2 = ?$~~ $\Delta\vec{r} = \vec{r}_2 - \vec{r}_1$

$\vec{V}_1 + \Delta\vec{r} = \vec{r}_2$

$\vec{r}_1 = r_1 \cos 35\,\hat{i} + r_1 \sin 35\,\hat{j}$

$\vec{r}_1 = (12.2872\,\hat{i} + 8.60365\,\hat{j})\,m$

$\vec{r}_2 = r_1 \cos 45\,\hat{i} + r_2 \sin 45\,\hat{j}$

$\vec{r}_2 = (17.6777\,\hat{i} + 17.6777\,\hat{j})\,m$

$\Delta\vec{r} = \vec{r}_2 - \vec{r}_1 = [17.6777\,\hat{i} + 17.6777\,\hat{j}] - [12.2872\,\hat{i} + 8.60365\,\hat{j}]$

$\Delta\vec{r} = [5.3904\,\hat{i} + 9.0740\,\hat{j}]\,m$

$\|\Delta\vec{r}\| = \sqrt{5.3904^2 + 9.074^2} = 10.6\ m$

Video Lecture #9 – Introduction to the R Position Vector by way of an Example Problem

$\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$ identifies location

$\Delta\vec{r} = \vec{r}_f - \vec{r}_i$ $\quad \frac{\Delta\vec{r}}{\Delta t} = \text{velocity}_{avg}$ $\quad \frac{d\vec{r}}{dt} = \text{velocity}_{inst}$

4-6| $\vec{r} = [3.00\,\hat{i} - 6.00t^2\,\hat{j}]\,m$

a) $v(t) = ?$ $\quad a(t) = ?$

b) $v(1.00) = ?$ $\quad a(1.00) = ?$

$\vec{r} = 3\hat{i} - 6t^2\hat{j}$ $\quad \frac{d\vec{r}}{dt} = \frac{d}{dt}[3\hat{i} - 6t^2\hat{j}]$

$v(t) = [-12.0\,t\,\hat{j}]\ m/s = -12(1) = -12.0\ m/s$

$a(t) = \frac{dv}{dt} = -12.0\,\hat{j}\ m/s^2 = -12.0\ m/s^2$

Video Lecture #10 – Using the R Position Vector to find Velocity and Acceleration - Example Problem

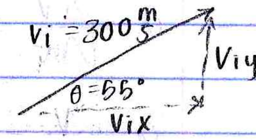
UAM

$x_f = x_i + v_i t + \frac{1}{2} a t^2$

$\vec{r}_f = \vec{r}_i + \vec{v}_i\,t + \frac{1}{2}\vec{a}\,t^2$

4-10 | $V_i = 300$ m/s @ 55.0° above horiz.

$\Delta t = 42.0$ s $\Delta x = ?$ $\Delta y = ?$



x-dir

$\Delta t = 42.0$ s

$V_{ix} = 172.0729$ m/s

$\Delta x = V_x \Delta t$

$\Delta x = (172.0729)(42)$

$= 7227.063$

≈ 7230 m

y-dir

$\Delta t = 42.0$ s

$a_y = -9.8$ m/s²

$V_{iy} = 248.745$ m/s

$\Delta y = V_{iy} t + \frac{1}{2} a_y t^2$

$\Delta y = 245.7456(42) + \frac{1}{2}(-9.8)(42)^2$

$\Delta y = 1677.715 \approx 1680$ m

4-10 w/unit vectors

$\vec{v_i} = (172.0729\hat{i} + 245.7456\hat{j})$ m/s

$\vec{r_i} = [0, 0]$ m $\vec{r_f} = [x, y]$ m

$\vec{a} = [0\hat{i} - 9.8\hat{j}]$ m/s²

$\vec{r_f} = \vec{r_i} + \vec{v_i}\Delta t + \frac{1}{2}\vec{a}\Delta t^2$ $\vec{r_f} = [0, 0] + [172.0729\hat{i} + 245.7456\hat{j}](42) + \frac{1}{2}(-9.8\hat{j})(42)^2$

$\vec{r_f} = 7227.061\hat{i} + 10341.3152\hat{j} - 8642.6\hat{j}$

$= 7227.061\hat{i} + 1677.715\hat{j} = (7230\hat{i} + 1680\hat{j})$ m

Video Lecture #12 – Introduction to Uniform Circular Motion

$\alpha = 0$ uniform circular motion

linear velocity ≠ constant (direction changes)

Angular velocity = constant (ω)

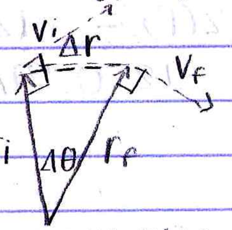
there must be acc.

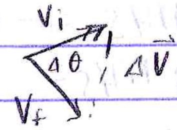
a_c centripital acc.

center seeking $a_c = \frac{v_t^2}{r} = r\omega^2$

Video Lecture #13 – Derivation of Centripetal Acceleration

$a = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t_f - t_i}$ $\alpha = 0$





$\|r_i\| = \|r_f\| = r$

$\|v_i\| = \|v_f\| = v$

inward toward center of circle

similar triangles

$\frac{\Delta v}{v} = \frac{\Delta r}{r}$ $\Delta v = \frac{\Delta r\, v}{r}$

$a = \frac{\Delta v}{\Delta t} = \frac{\Delta r\, v}{\Delta t\, r}$ $a = \frac{v}{r}\frac{\Delta r}{\Delta t}$ $\Delta t \rightarrow 0$

$a = \frac{v}{r}\frac{dr}{dt} = \frac{v}{r} \cdot v = \frac{v^2}{r}$

Video Lecture #14 – Deriving the relationship between Angular Velocity and Period

$\omega = \frac{\Delta\theta}{\Delta t}$ rad/s $= \frac{2\pi}{T}$ rad $T = \frac{2\pi}{\omega}$

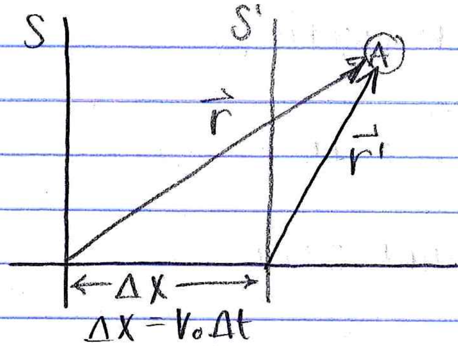
Video Lecture #15 – Explaining the Differences between Tangential and Centripetal Accelerations

a_t tangential acc (tang. to circle) caused by change in magnitude of v_t

a_c centripital acc (inward) If you have circular motion, must have a_c

$\vec{a} = \vec{a}_t + \vec{a}_c$ $a_t = 0 \rightarrow$ UCM

$a_c = 0 \rightarrow$ not moving in O



S is stationary wrt Earth

S' is moving @ V_0 (const vel) wrt Earth

$V_0 \Rightarrow$ const. vel of S'

$V_0 = \frac{\Delta X}{\Delta t} \Rightarrow \Delta X = V_0 \Delta t$

$t_i = 0 \Rightarrow \Delta X = V_0 t$

(S is moving @ $\underline{-V_0}$ wrt S')

$\vec{r} = \vec{r}' + \Delta X$

$\vec{r} = \vec{r}' + V_0 t$

$\frac{d}{dt}\left(\vec{r}' = \vec{r} - V_0 t\right) \quad \frac{d\vec{r}'}{dt} = \frac{d\vec{r}}{dt} - \frac{d}{dt}(V_0 t)$

$v' = v - V_0$

v' is velocity of Ⓐ wrt S' frame

v is velocity of Ⓐ wrt S frame

$\frac{d}{dt}\left(v' = v - V_0\right) \quad \frac{dv'}{dt} = \frac{dv}{dt} - \frac{dV_0}{dt}$

$\vec{a}' = \vec{a} - 0 \quad \vec{a}' = \vec{a}$

If $a = 0$ an inertial reference frame

If $a \neq 0$ a non-inertial reference frame

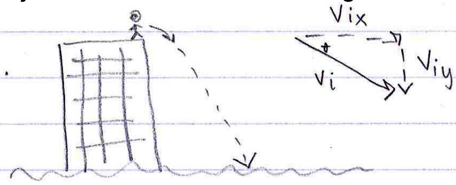
(Part 1 & 2) Throwing a Ball off a Building - A Projectile Motion Problem using Unit Vectors

4-17. $v_i = 8.00$ m/s @ 20.0° below Horiz.

$\Delta t = 3.00$ sec

a) $\Delta x = ?$ c) $\Delta t = ?$ when

b) $h_i = ?$ $\Delta y = -10.0$ m



$\vec{r}_f = \vec{r}_i + \vec{v}_i t + \frac{1}{2}\vec{a}t^2$

* $v_i = v_{ix}\hat{i} + v_{iy}\hat{j}$

$= v_i\cos\theta\hat{i} + v_i\sin\theta\hat{j}$ down

$= 8\cos(20)\hat{i} - 8\sin(20)\hat{j}$

$\vec{v}_i = [7.51754\hat{i} - 2.73616\hat{j}]$ m/s

* $\vec{a} = [0\hat{i} - 9.8\hat{j}]$ m/s²

* $\vec{r}_i = [0\hat{i} + y\hat{j}]$ m $\vec{r}_f = [x\hat{i} + 0\hat{j}]$ m.

(* same for part c.)

$x\hat{i} = y\hat{j} + [7.51754\hat{i} - 2.73616\hat{j}](3) + \frac{1}{2}(-9.8\hat{j})(3)^2$

$x\hat{i} = y\hat{j} + 22.55262\hat{i} - 8.20848\hat{j} - 44.1\hat{j}$

$x\hat{i} = y\hat{j} + 22.55262\hat{i} - 52.30848\hat{j}$

$(\hat{i}) \Rightarrow x = 22.55262$

$x \approx 22.6$ m

$(\hat{j}) = 0 = y - 52.30848$

≈ 52.3 m

(c). * are same.

$\vec{r}_f = [x\hat{i} + [52.30848 - 10]\hat{j}]$ m

$\vec{r}_f = [x\hat{i} + 42.30848\hat{j}]$ m

$\vec{r}_f = \vec{r}_i + \vec{v}_i t + \frac{1}{2}at^2$

$[x_i + 42.30848\hat{j}] = [y\hat{j}] + [7.5174\hat{i} - 2.73616\hat{j}]t + \frac{1}{2}(-9.8)t^2$

$x_i + 42.30848\hat{j} = 52.30848\hat{j} + 7.5174\hat{i} - 2.73616\hat{j} - 4.9\hat{j}t^2$

$(\hat{j})\ 42.30848 = 52.30848 - 2.73616t - 4.9t^2$

$0 = 10 - 2.73616t - 4.9t^2$

$$\frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-(-2.73616) \pm \sqrt{(-2.73616)^2 - 4(-4.9)(10)}}{2(-4.9)}$$

$$t = \frac{2.73616 \pm 14.26487}{-9.8}$$

$t = -0.2792 \pm 1.4556$

$t = 1.1764$ or -1.7348

$t \approx 1.18$ sec.