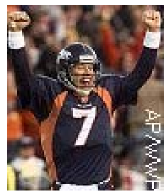
“And in 1999, We Come to Super Bowl XXXIII Held in Miami, Florida…” (50,000 points)

1.) This is based on data from the *Nike*™-**Budweiser**®-Apple™-`www.nfl.com`-Super Bowl XXXIII®™. With five minutes to go in the 2nd Quarter, Bronco QB #7 John Elway drops back and throws a pass that covers 50 yards (45.7 m) in 3.56 seconds, when the receiver, #80 Rod Smith, then runs with the ball another 40 yards (36.6 m) in 4.11 seconds for a touchdown. What is the average speed of the football?

$$v = \frac{d}{t} = \frac{45.7m + 36.6m}{3.56\sec + 4.11\sec} = \frac{82.3m}{7.67\sec} = 10.73m/s$$



(b) Rod Smith, goes from rest to 8.91 m/s in a distance of 2.00 meters. What is the average acceleration of the runner?

$$\begin{aligned} & v_0 = 0 \;\; ; \;\; x_0 = 0 \\ & v^2 = v_0^2 + 2a(x - x_0) \\ & v^2 = 2ax \\ & a = \frac{v^2}{2x} = \frac{(8.91m/s)^2}{2(2.00m)} \\ & \quad = 19.85m/s^2 \qquad (2\ gee's???) \end{aligned}$$

(c) #5 Morton Anderson of the Atlanta Falcons kicked off the football after their “first blood” field goal at 9:24 in the 1st quarter. The ball travels downfield 52 yards (47.5 m) in 5.85 sec. Neglecting air resistance, as usual, find v_{oy} and v_y when it lands again.

$$\begin{aligned} & v_y = 0 \text{ (To top of arc.)} \quad t = \tfrac{1}{2}(5.85s) = 2.925s \\ & v_y = v_{oy} - gt \\ & 0 = v_{oy} - gt \\ & v_{oy} = gt \\ & v_{oy} = gt = (9.81m/s^2)(2.925s) \\ & \quad = +28.69m/s \\ & v_y = -28.69m/s \end{aligned}$$

OR

$$\begin{aligned} & v_y = -v_{oy} \text{ (For symmetrical jump.)} \\ & v_y = v_{oy} - gt \\ & -v_{oy} = v_{oy} - gt \\ & -2v_{oy} = -gt \\ & v_{oy} = \frac{gt}{2} = \frac{(9.81m/s^2)(5.85s)}{2} \\ & \quad = +28.69m/s \\ & v_y = -28.69m/s \end{aligned}$$

(d) How high does the football go? *This can be solved without an answer to (c).*

$$\begin{aligned} & y = y_0 + v_{0y}t - \tfrac{1}{2}gt^2 \\ & \quad = v_{0y}t - \tfrac{1}{2}gt^2 \\ & \quad = (28.69m/s)(2.925s) - \tfrac{1}{2}(9.81m/s^2)(2.925s)^2 \\ & \quad = 41.95m \end{aligned}$$

OR

$$\begin{aligned} & h = \tfrac{1}{2}gt^2 \\ & \quad = \tfrac{1}{2}(9.81m/s^2)(2.925s)^2 \\ & \quad = 41.95m \end{aligned}$$

OR

$$h = \frac{v_0^2 \sin^2\theta}{2g} = \frac{(29.82m/s)^2 \sin^2(74.2°)}{2(9.81m/s^2)} = 41.96m$$

(e) Find the initial velocity vector, $\vec{v}_0$, of the football. Give the answer in Standard Form. *If you did not get an answer to (c), use v_{oy} = 9.81 m/s.*

$$\begin{aligned} & v_{0x} = \frac{d}{t} = \frac{47.5m}{5.85s} = 8.120m/s \quad ; \quad v_{0y} = 28.69m/s \\ & v_0 = \sqrt{v_{0x}^2 + v_{0y}^2} = \sqrt{(8.120m/s)^2 + (28.69m/s)^2} = 29.82m/s \\ & \theta = \tan^{-1}\left(\frac{v_y}{v_x}\right) \\ & \quad = \tan^{-1}\left(\frac{28.69m/s}{8.120m/s}\right) = 74.2° \\ & \vec{v}_0 = 29.82m/s \ @ \ 74.2° \end{aligned}$$

"You Have No Concept of the Power of Star Problems!" DARTH VADER **(50,000 points)**

2.) An object's equation of motion is $\frac{d^6x}{dt^6} = 6.00 m/s^6$, with $v_0 = 6.00$ *m/s. All other constants are zero.*

☆(a) Find the equation for the position of this object.

$$x = \int \frac{dx}{dt}\,dt = \int \left[(0.05000\ m/s^6)\,t^5 + 6.00 m/s\right]dt$$
$$= \tfrac{1}{6}(0.05000\ m/s^6)\,t^6 + (6.00 m/s)\,t + C \quad ; \quad (C = x_0 = 0)$$
$$= (0.008333\ m/s^6)\,t^6 + (6.00 m/s)\,t$$

☆(b) Find the equation for the speed of this object.

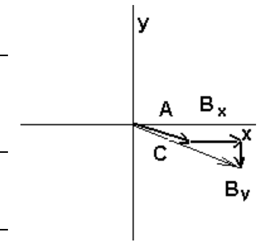
$$v_x = \frac{dx}{dt} = \int \frac{d^2x}{dt^2}\,dt = \int (0.2500\ m/s^6)\,t^4\,dt$$
$$= \tfrac{1}{5}(0.2500\ m/s^6)\,t^5 + C \quad ; \quad (C = v_0 = 6.00 m/s)$$
$$= (0.05000\ m/s^6)\,t^5 + 6.00 m/s$$

☆(c) Find the equation for the acceleration of this object.

$$a_x = \frac{d^2x}{dt^2} \quad ; \quad \frac{d^6x}{dt^6} = +6.00\ m/s^6$$
$$\frac{d^5x}{dt^5} = \int \frac{d^6x}{dt^6}\,dt = \int \left[6.00\ m/s^6\right]dt$$
$$= (6.00\ m/s^6)\,t + C \quad ; \quad (C = 0)$$
$$\frac{d^4x}{dt^4} = \int \frac{d^5x}{dt^5}\,dt = \int (6.00\ m/s^6)\,t\,dt$$
$$= \tfrac{1}{2}(6.00\ m/s^6)\,t^2 + C \quad ; \quad (C = 0)$$
$$\frac{d^3x}{dt^3} = \int \frac{d^4x}{dt^4}\,dt = \int \tfrac{1}{2}(6.00\ m/s^6)\,t^2\,dt$$
$$= \tfrac{1}{2\cdot 3}(6.00\ m/s^6)\,t^3 + C \quad ; \quad (C = j_0 = 0)$$
$$\frac{d^2x}{dt^2} = \int \frac{d^3x}{dt^3}\,dt = \int \tfrac{1}{2\cdot 3}(6.00\ m/s^6)\,t^3\,dt$$
$$\tfrac{1}{2\cdot 3\cdot 4}(6.00\ m/s^6)\,t^4 + C \quad ; \quad (C = a_0 = 0)$$
$$a_x = (0.2500\ m/s^6)\,t^4$$

(d) Sketch the vector $\vec{C} = \vec{A} + \vec{B}$, where $\vec{A}$ = *3.44 m @ 342°* and $\vec{B} = +5.71 m\,\hat{i} - 2.60 m\,\hat{j}$.
Find $\vec{C}$ in Standard Form .

	$A_x = A\cos\theta$	$A_y = A\sin\theta$
$\vec{A}$ = 12.0 m @ 162°	(3.44 m)(cos 342°)	(3.44 m)(sin 342°)
	+3.272 m	-1.063 m
$\vec{B} = -11.3m\,\hat{i} - 12.6m\,\hat{j}$	+5.71 m	-2.60 m
$\vec{C} = \vec{A} + \vec{B}$	C_x = 8.982 m	C_y = -3.663 m



$$C = \sqrt{C_x^2 + C_y^2} = \sqrt{(8.982m)^2 + (-3.663m)^2} = 9.700m$$
$$\theta = \tan^{-1}\left(\frac{C_y}{C_x}\right)$$
$$= \tan^{-1}\left(\frac{-3.663m}{8.982m}\right) = -22.2° = 337.8°$$
$$\vec{C} = 9.700m\ @\ 337.8°$$

☆(e) An object has its motion given as $a(t) = (6.00 m/s^2)$. Find the second derivative of x with respect to time at time t = *1.00 sec.*

$$a \equiv \frac{d^2x}{dt^2}$$
$$So\ \ a = \frac{d^2x}{dt^2} = 6.00 m/s^2$$
$$at\ \ t = 1.00\,\text{sec},\ still\ \ is\ \ 6.00 m/s^2$$