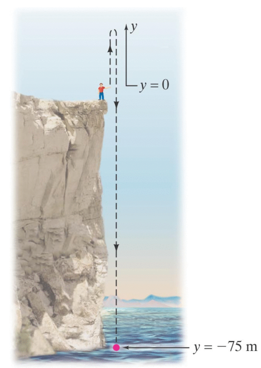
HW02-29 : A car traveling 25.0 m/s passes a second car which is at rest. When the cars are right next to each other, the first car slows down at a constant rate of 2.0 m/s^2 and the second car starts to accelerate at the same constant rate. When will the two cars be next to each other again?

HW02-42 : Determine the stopping distance for an automobile going a constant initial speed of 95 km/hr in the $+X$ direction, and human reaction time of 0.40 s: (a) for an acceleration of $a = -2.5$ m/s^2 and (b) for $a = -5.5$ m/s^2.

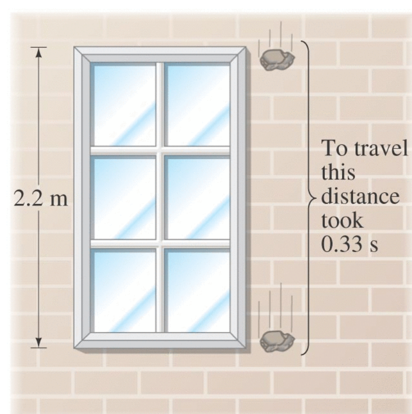
HW02-46 : A space vehicle accelerates uniformly from 85 m/s at $t = 0$ to 162 m/s at $t = 10.0$ s. How far did it move between $t = 2.0$ s and $t = 5$ s.

(Hint: use the given information to construct the position equation of motion for the object.)

HW02-63 : A stone is thrown vertically upward with a speed of 15.5 m/s from the edge of a cliff 75 m high. (a) How much later does it reach the bottom of the cliff? (b) What is its speed just before hitting? (c) What total **distance** did it travel?



HW02-69 : A falling stone takes 0.33 s to travel past a window that is 2.2 m tall. From what height (above the top of the window) did the stone fall (assume it was released from rest).
(Probably too tricky for a first test, but give it a try. Try using a downward pointing coordinate system where $y = 0$ is where the stone was released at rest, and $a = +9.8$ m/s^2 since our coordinate is pointing downward. Try using the position equation of motion for the stone. At some time t the stone passes the top of the window at a location of y_{top}. At $t + 0.33$ s, it reaches the point $y_{top} + 2.2$. Ultimately if we can find y_{top} we're done.)



HW03-06 : Vector $\vec{V_1}$ is 6.2 units long and points along the negative X axis. Vector $\vec{V_2}$ is 8.1 units long and points at $+55^o$ relative to the positive X axis. (a) What are the x and y components of each vector? (b) Determine $\vec{V_3} = \vec{V_1} + \vec{V_2}$, expressing your result in unit vector notation, then in polar notation (magnitude and angle measured positive counter-clockwise starting from the $+X$ axis).

(A sketch showing the two vectors will be useful here.)

HW03-21 : A car is moving with speed 16 m/s due south (the $-Y$ direction) at one moment, and at 25.7 m/s due east (the $+X$ direction) exactly 8 seconds later. Over this time interval assume the acceleration is constant and determine the magnitude and direction of (a) it's average velocity, and (b) it's average acceleration.

(Remember, terms like 'velocity' and 'acceleration' refer to vectors.)

HW03-22 : At $t = 0$ a particle starts from rest at $x = 0, y = 0$ and moves in the xy plane with an acceleration of $\vec{a} = (4.0\hat{\imath} + 3.0\hat{\jmath})\ m/s^2$. Determine (a) the x and y components of velocity, (b) the speed of the particle, and (c) the position of the particle, all as a function of time. (d) Evaluate all the above at $t = 2\ s$.

(Note they're looking for equations as a function of time for the first three parts, which you'll then evaluate at the given time for part (d).)

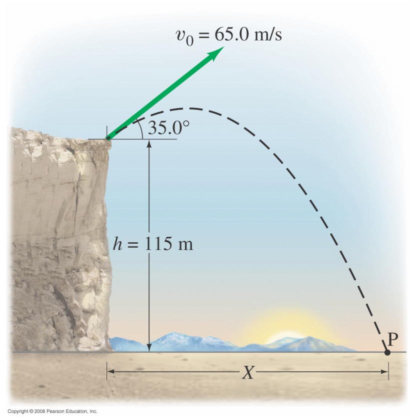
HW03-26 (modified) : Suppose the position of an object is given by $\vec{r} = (3.0t^2\hat{\imath} - 6.0t^3\hat{\jmath})\ m$. (a) Determine it's velocity $\vec{v}$ and acceleration $\vec{a}$ as functions of time. (b) What was the object's average velocity (vector) between $t = 1\ s$ and $t = 5\ s$? (c) What was the objects instantaneous velocity at $t = 3\ s$?

(Note that this object's position function involves t^3 so acceleration is not constant here.)

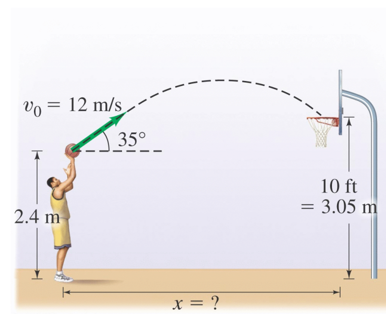
HW03-38 : You buy a plastic dart gun, and being a clever physics student you decide to do a quick calculation to find its maximum horizontal range. If you shoot the gun straight up, it takes 3.4 s for the dart to land back at the barrel. What is the maximum horizontal range of your gun?

(Remember in our range (R) equation, R_{max} occurs when an object is launched at a 45^o angle. What does the information given tell you about how fast the dart is moving when it leaves the dartgun?)

HW03-42 : (A test problem would likely just ask for just a couple of these parts.) A projectile is shot from the edge of a cliff 115 m above ground level with an initial speed of 65 m/s at an angle of 35^o above the horizontal, as shown in the figure. (a) Determine the time taken by the projectile to hit point P at ground level. (b) Determine the distance of point P from the base of the vertical cliff. At the instant just before the projectile hits point P, find (c) the horizontal and vertical components of its velocity, (d) the magnitude of that velocity, and (e) the angle made by the velocity vector with the horizontal. Finally, (f) find the maximum height above the cliff top reached by the projectile.

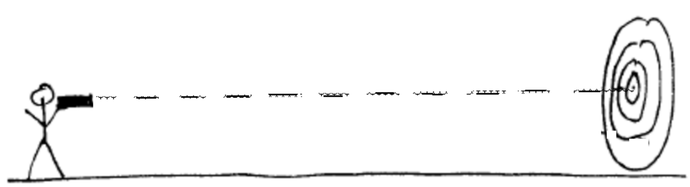


HW03-90 : A basketball is shot from an initial height of 2.4 m with an initial speed of $v_o = 12\ m/s$ at an angle of $\theta_o = 35^o$ above the horizontal. The ball passes through a hoop that is 3.05 m above the floor. (a) How far from the basket was the player? (b) At what angle relative to the horizontal did the ball enter the basket?



(The ball launches and lands at different heights, so you can't use the special Range (R) equation here. There are at least two approaches here though, starting with equations of motion, or using the special $y(x)$ equation. In each case, watch out for the potential of two answers since the ball passes through $y = 3.05\ m$ both on the way up and then again on the way down.)

Arrow (1) : An arrow is fired at a target that's set up so that the bullseye is at the same elevation as the point the arrow was fired from. If we aim up 3^o above the horizontal and fire the arrow at 40 m/s, we find that the arrow hits the bullseye. How far away was the target?



Arrow launch point at same elevation as bullseye

Arrow (2) : An arrow is fired at a target that's set up so that the bullseye is at the same elevation as the point the arrow was fired from. If we aim up 3^o above the horizontal and fire the arrow at 40 m/s, we find that the arrow lands 20 cm below the bullseye. How far away was the target?

HW02-29 : $t = 12.5\ s$ (at which point each has travelled $156.25m$)

HW02-42 : (a) 10.56 m during first 0.4 s plus 139.27 m during braking; so 149.8 m.
(b) 10.56 m during first 0.4 s plus 63.31 m during braking; so 73.86 .

HW02-46 : given info implies $a = 7.7\ m/s^2$. Use that to find $\Delta x = 335.85\ m$. (Multiple paths to this, but all seem to require finding the acceleration...)

HW02-63 : (a) 5.80155 s; (b) $|v| = 41.355..\ m/s$; (c) 99.515.. m (travels up some distance, then down that same distance, then down another 75 m to reach the bottom of the cliff).

HW02-69 : just 1.3 m above the top of the window.

HW03-06 : (a) $V_{1x} = -6.2$, $V_{1y} = 0$; and $V_{2x} = +4.646$, $V_{2y} = +6.635$;
(b) $\vec{V}_3 = -1.554\hat{i} + 6.635\hat{j}$ or $\vec{V} = (6.815, 103.2^o)$

HW03-21 (CORRECTED) :
(a) $v_{avg} = \frac{\vec{v}_1+\vec{v}_2}{2} = (12.85\hat{i} - 8.00\hat{j})\ m/s$
(b) $a_{avg} = \frac{\vec{v}_2-\vec{v}_1}{\Delta t} = (3.2125\hat{i} + 2.00\hat{j})\ m/s^2$

HW03-22 (CORRECTED) :
(a) $v_x(t) = 4t$, $v_y(t) = 3t$; (b) $v(t) = 5.0t$; (c) $\vec{r}(t) = (2\hat{i} + 1.5\hat{j})t^2$;
(d) $v_x(2) = 8.0\ m/s$, $v_y(2) = 6.0\ m/s$, $v(2) = 10.0\ m/s$; $\vec{r}(2) = (8\hat{i} + 6\hat{j})\ m$.

HW03-26 (CORRECTED) :
(a) $\vec{v}(t) = d\vec{r}/dt = (6.0t\hat{i} - 18.0t^2\hat{j})\ m/s$ and $\vec{a}(t) = d\vec{v}/dt = (6.0\hat{j} - 36.0t\hat{j})\ m/s^2$.
(b) Acceleration is **not constant** here, so need to use $\vec{v}_{avg} = \frac{\Delta\vec{r}}{\Delta t}$. Evaluate at each time to find: $\vec{v}_{avg} = (18\hat{i} - 186\hat{j})\ m/s$. (c) Instantaneous: $\vec{v}(3) = (18\hat{i} - 162\hat{j})\ m/s$

HW03-38 : That time implies a vertical launch speed of $v_o = 16.66\ m/s$; that launch speed at 45^o yields a max range of 28.322 m.

HW03-42 : (Launches and lands at different elevations, so use full equations of motion here.) (a) $t = 9.964\ s$; (b) $x = 530.54\ m$; (c) Hits ground with: $v_x = 53.245\ m/s$, $v_y = -60.365\ m/s$ (d) speed: $|v| = 80.492\ m/s$; (e) angle: 48.6^o below the horizontal; (f) 70.92 m above the launch point.

HW03-90 : Generic equations of motion again; note the ball reaches that elevation TWICE: once on the way up, then again on the way down (through the hoop). (a) distance: 12.8 m; (b) 30.9^o below the horizontal.

Arrow (1) : (a) the special 'range' equation works here, so 17.066 m.

Arrow (2) : (a) the special 'range' equation does NOT work here, so need to use the usual equations of motion (X and Y). Result: 20.28 m away.

Common Conversions			Prefixes	
Length	Volume	Velocity	Value	Name
$1\ in = 2.540\ cm$	$1\ gal = 3.788\ L$	$1\ mi/h = 1.466\ ft/s$	10^{-9}	nano (n)
$1\ m = 39.37\ in$	$1\ gal = 231.1\ in^3$	$1\ mi/h = 0.4470\ m/s$	10^{-6}	micro (μ)
$1\ m = 3.281\ ft$	$1\ L = 1000\ cm^3$	$1\ mi/h = 1.609\ km/h$	10^{-3}	milli (m)
$1\ ft = 0.3048\ m$	$1\ L = 1.057\ qt$	$1\ m/s = 2.237\ mi/h$	10^{-2}	centi (c)
$1\ km = 0.6214\ mile$	$1\ L = 0.0353\ ft^3$		10^{3}	kilo (k)
$1\ mile = 1609\ m$	$1\ ft^3 = 28.32\ L$		10^{6}	mega (M)

Uncertainty: $x \pm \Delta x$ Fractional uncertainty: $\Delta x/x$ Percent uncertainty: $100\Delta x/x$
Circle: $C = 2\pi r$ $A = \pi r^2$ | **Sphere**: $C = 2\pi r$ $A = 4\pi r^2$ $V = \frac{4}{3}\pi r^3$
Quadratic equation If $Ax^2 + Bx + C = 0$ then $x = \frac{-B\pm\sqrt{B^2-4AC}}{2A}$

Polar: $\vec{A} = (A, \theta)$: magnitude and angle (CCW) with $+X$ axis.
Cartesian: $\vec{A} = (A_x, A_y, A_z)$ or $\vec{A} = A_x\hat{i} + A_y\hat{j} + A_z\hat{k}$ $|\vec{A}| = \sqrt{A_x^2 + A_y^2 + A_z^2}$

Average velocity: $v_{avg} = \frac{x_B - x_A}{t_B - t_A} = \frac{\Delta x}{\Delta t}$ **Instantaneous**: $v = dx/dt$.

Average acceleration: $a_{avg} = \frac{v_B - v_A}{t_B - t_A} = \frac{\Delta v}{\Delta t}$ **Instantaneous**: $a = dv/dt$.

Straight-line (1D) motion with constant acceleration.
$v = v_o + at$ $v_{avg} = v_o + \frac{1}{2}at$ $v_{avg} = \Delta x/\Delta t$ $v_{avg} = \frac{1}{2}(v + v_o)$
$x = x_o + v_o t + \frac{1}{2}at^2$ $x - x_o = (\frac{v_o + v}{2})t$ $v^2 = v_o^2 + 2a(x - x_0)$
Freely-falling bodies: $\vec{a} = \vec{g}$, where $g = |\vec{g}| = +9.80\ m/s^2$.

$\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$ $\vec{r} = \vec{r}_o + \vec{v}_{avg}t$	$\vec{v}_{avg} = \Delta\vec{r}/\Delta t$ $\vec{v} = d\vec{r}/dt$	$\vec{a}_{avg} = \Delta\vec{v}/\Delta t$ $\vec{a} = d\vec{v}/dt$
Vector Equations of Motion if $\vec{a}$ is constant		
$\vec{v} = \vec{v}_o + \vec{a}t$	$\vec{v}_{avg} = (\vec{v}_o + \vec{v})/2 = \vec{v}_o + \frac{1}{2}\vec{a}t$	$\vec{r} = \vec{r}_o + \vec{v}_o t + \frac{1}{2}\vec{a}t^2$
Component Form		
$v_x = dx/dt$ $a_x = dv_x/dt$ $v_x = v_{ox} + a_x t$ $x = x_o + v_{ox}t + \frac{1}{2}a_x t^2$ $v_x^2 = v_{ox}^2 + 2a_x\Delta x$	$v_y = dy/dt$ $a_y = dv_y/dt$ $v_y = v_{oy} + a_y t$ $y = y_o + v_{oy}t + \frac{1}{2}a_y t^2$ $v_y^2 = v_{oy}^2 + 2a_y\Delta y$	$v_z = dz/dt$ $a_z = dv_z/dt$ $v_z = v_{oz} + a_z t$ $z = z_o + v_{oz}t + \frac{1}{2}a_z t^2$ $v_z^2 = v_{oz}^2 + 2a_z\Delta z$
$v^2 = v_o^2 + 2a_x\Delta x + 2a_y\Delta y + 2a_z\Delta z$		

(continued on next page...)

Projectile Motion: $\vec{a} = \vec{g}$ with $g = |\vec{g}| = +9.80\ m/s^2$. If +Y points upward ($a_x = 0$, $a_y = -g$) then:
$x = x_o + v_{ox}t$ $\quad v_x = v_{ox}$ $\quad y = y_o + v_{oy}t - \frac{1}{2}gt^2$ $\quad v_y = v_{oy} - gt$

If launched at origin with $\vec{v}_o = (v_o, \theta)$: $v_{ox} = v_o \cos\theta$ $\quad v_{oy} = v_o \sin\theta$
$x = (v_o \cos\theta)t$ $\quad y = (v_o \sin\theta)t - \frac{1}{2}gt^2$ $\quad y = (\tan\theta)x - (\frac{g}{2v_o^2 \cos^2\theta})x^2$

Apogee: $h = \frac{v_o^2 \sin^2\theta}{2g}$ above the launch point. $t_A = \frac{v_o \sin\theta}{g}$

If $y_{final} = y_{initial}$: Range $R = \frac{v_o^2 \sin(2\theta)}{g}$ $\quad R_{max} = \frac{v_o^2}{g}$ at $\theta = 45^o$ $\quad$ Total flight time: $t = 2t_A$

Trig: $\sin(2\theta) = 2\sin(\theta)\cos(\theta)$