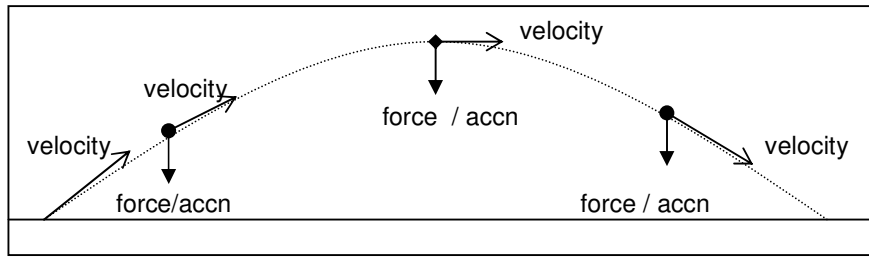


parabolic nature of path

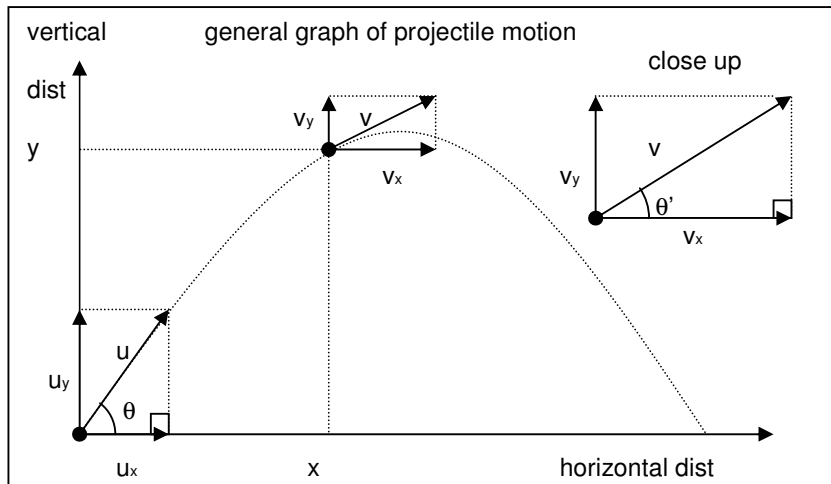
- look at a long exposure photograph of fireworks or metal work sparks.
- the points of light are projectiles and they trace out curved paths.
- the path is always **parabolic**, whether thrown horizontally or upwards at an angle or downwards at an angle.



Key points

- the path of a projectile is always parabolic.

solving projectile problems



- consider a projectile launched with an initial velocity u and at an angle of θ to the horizontal
- the motion can be resolved into its horizontal and vertical components:
- the initial horizontal velocity u_x is given by

$$u_x = u \cos \theta.$$

-the initial vertical component u_y is given by

$$u_y = u \sin \theta.$$

-all three vectors are related by

$$u^2 = u_x^2 + u_y^2.$$

-at some time later, t , the projectile has co-ordinates (x,y) .

-it has a new final velocity v at a new angle θ' .

-the final horizontal component is given by

$$v_x = v \cos \theta'.$$

-the final vertical component is given by

$$v_y = v \sin \theta'.$$

-all three vectors are related by

$$v^2 = v_x^2 + v_y^2.$$

-as there is no horizontal force, the horizontal velocity is constant so

$$v_x = u_x.$$

- u_x , x and t are related simply by

$$x = u_x t.$$

-the vertical motion is uniformly accelerated motion:

| | |
|--------------------------------|-------------------------------------|
| $v_y = u_y + gt$ | (from $v = u + at$) |
| $y = u_y t + \frac{1}{2} gt^2$ | (from $s = ut + \frac{1}{2} at^2$) |
| $y = (v_y + u_y)t/2$ | (from $s = (v+u)t/2$) |
| $v_y^2 - u_y^2 = 2gy$ | (from $v^2 - u^2 = 2as$) |

-here g is the acceleration due to gravity.

-up is taken as positive, down as negative
so gravity $g = -10. \text{m/s}^2$.

-example, see the diagram opposite.

-consider a football kicked with an initial velocity of $u = 24 \text{m/s}$.

-the ball leaves the ground at an angle of $\theta = 36^\circ$ to the horizontal.

-how long does the ball take to reach the top of its path?

-first find the vertical component from

$$u_y = u \sin \theta.$$

$$u_y = 24 \sin 36 = 14.1 \text{m/s}$$

-at the top of the path, the vertical component $v_y = 0$

$$v_y = u_y + gt, \text{ so } 0 = 14.1 - 10t \quad \text{and rearranging}$$

$$t = 1.41 \text{s (1.4s)}$$

-how high did the football reach?

-using $y = (v_y + u_y)t/2$

