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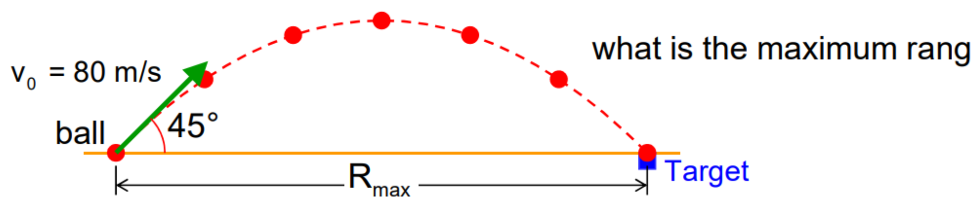
Projectile Motion

Example 1:



g=9.8 m/s^2

Solve

The maximum range corresponds to elevation angle θ_0 of 45^0

$$R_{max} = \frac{v_0^2}{g}\sin 2(45°) = \frac{v_0^2}{g} = 653 \text{ m}$$

Example 2:

A long- jumper leaves the ground at an angle of 20° above the horizontal and at a speed of 11 $\left(\frac{m}{s}\right)$

a. How far does he jump in horizontal direction?
b. What is maximum height reached?

Solve

a. $R = \frac{v_0^2 sin2\theta}{g} = \frac{(11)^2 sin2(20)}{9.8} = 7.936\ m$

b. $h = \frac{v_0^2 sin^2\theta}{2g} = \frac{(11)^2 sin^2 20}{2\times 9.8} = 0.722\ m$

Example 3:

Suppose a golfer hits a ball with a velocity of 45 m/s at an angle of 20° to the horizontal. Finding the position at a later time where will the ball be 2 seconds later?

Solve

Horizontal motion

Using $x = V\cos\alpha\, t$ with V = 45, α = 20° and t = 2

gives x = 45 cos 20° × 2 = 84.57 .... (metres)

Vertical motion

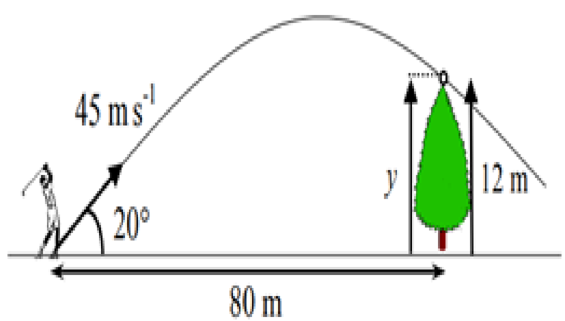
Using $y = V\sin\alpha\, t - \frac{1}{2}gt^2$ with V = 45, α = 20°, g = 9.8 and t = 2

gives $y = 45\sin 20° \times 2 - \frac{1}{2} \times 9.8 \times 2^2$ = 11.18... (metres)

After 2 seconds the ball will be at the point (84.6, 11.2) to 3 sf.

Example 4 :

For example, if the golf ball is hit in the direction of a 12 metre tree which is 80 metres from the golfer, will the ball pass over the tree or hit it?



Solve

Horizontal motion

Using $x = V\cos\alpha\, t$ with $x = 80$, $V = 45$ and $\alpha = 20°$

gives $80 = 45\cos 20° t \Rightarrow t = \dfrac{80}{45\cos 20°} = 1.8918...$

Vertical motion

Using $y = V\sin\alpha\, t - \frac{1}{2}gt^2$ with $V = 45$, $\alpha = 20°$, $t = 1.892$ and $g = 9.8$

gives $y = 45\sin 20° \times 1.892 - 4.9 \times 1.892^2 = 11.579...$

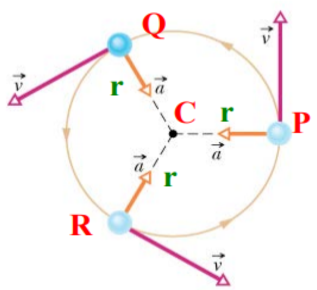
This is less than 12 metres, so the ball will hit the tree.

Uniform Circular Motion

A particle is in uniform **circular motion** it moves on a circular path of **radius r** with **constant speed v**. Even though the speed is constant, the velocity is not. The reason is that the direction of the velocity vector changes from point to point along the path**. The fact that the velocity changes means that the acceleration is not zero.**

يتحرك الجسيم في حركة دائرية منتظمة، ويتحرك في مسار دائري نصف قطره r وبسرعة ثابتة v. وعلى الرغم من أن الانطلاق ثابتة، إلا أن السرعة ليست كذلك. والسبب هو أن اتجاه متجه السرعة يتغير من نقطة إلى أخرى على طول المسار. **وحقيقة أن السرعة تتغير تعني أن التعجيل التسارعي ليس صفرًا.**

Its magnitude a is given by the equation: $\boxed{a = \frac{v^2}{r}}$



The time T it takes to complete a full revolution is known as the "period". It is given by the equation:

$$\boxed{T = \frac{2\pi r}{v}}$$

Example 5:

In one model of the hydrogen atom, an electron orbits a proton in a circle of radius 5.28×10^{-11} m with a speed of 2.18×10^{6} m s. (a) what is the acceleration of the electron in this model? (b) What is the period of the motion?

Solve:

a-

$$\mathbf{a = v^2/r = (2.18 \times 10^6\ m/s)^2 / (5.28 \times 10^{-11}\ m) = 9.00 \times 10^{22}\ m/s^2}$$

b- If T is the period of the motion, then the speed of the electron is given by the ratio of distance to time

$$v = \frac{2\pi r}{T} \qquad \text{which gives...} \qquad T = \frac{2\pi r}{v}$$

$$T = \frac{2\pi(5.28 \times 10^{-11}\ \mathrm{m})}{(2.18 \times 10^{6}\ \frac{\mathrm{m}}{\mathrm{s}})} = 1.52 \times 10^{-16}\ \mathrm{s}$$

Example 7:

An earth satellite moves in a circular orbit 640 km above Earth's surface with a period of 98.0 min. What are the (a) speed and (b) magnitude of the centripital acceleration of the satellite?

We apply $\boxed{T = \frac{2\pi r}{v}}$ to solve for speed v and $\boxed{a = \frac{v^2}{r}}$ to find acceleration a.

(a) Since the radius of Earth is 6.37×10^6 m, the radius of the satellite orbit is

$$r = (6.37 \times 10^6 + 640 \times 10^3)\ \mathrm{m} = 7.01 \times 10^6\ \mathrm{m}.$$

Therefore, the speed of the satellite is

$$v = \frac{2\pi r}{T} = \frac{2\pi(7.01 \times 10^6\ \mathrm{m})}{(98.0\ \mathrm{min})(60\ \mathrm{s/min})} = 7.49 \times 10^3\ \mathrm{m/s}.$$

(b) The magnitude of the acceleration is

$$a = \frac{v^2}{r} = \frac{(7.49 \times 10^3\ \mathrm{m/s})^2}{7.01 \times 10^6\ \mathrm{m}} = 8.00\ \mathrm{m/s^2}.$$