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Suggested Answers Discusssion / Activity 1

Projectiles

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1. What is a "projectile"?
An object which is launched with an initial velocity and then moves only under the influence of gravity.

2. For a projectile launched on or near the surface of the Earth:
a) what is the shape of the path it follows? Parabola
b) at what angle will the maximum range be achieved? 45^o
c) to analyse the Physics of a projectile, what is the "key" first-step? *(given initial velocity & launch angle)*
Resolve the intitial velocity vector into a horizontal component and a vertical component.
This allows horizontal & vertical motions to be analysed separately and re-combined by vector addition as needed.
d) what is the "key" characteristic of the horizontal velocity?
The horizontal velocity is constant.

e) describe the "key" characteristic of the vertical motion.
Uniform acceleration under gravity.

f) what is the instantaneous vertical velocity at the point of maximum height?
Before that point the velocity was upwards. After that point it is downwards. For an instant it is zero.

3. Give an outline of how the answer to 2(f) is vital to determining the values of max. height and range.
At max height, vertical velocity of zero allows the time of flight to be determined.
This allows the height value to be calculated from vertical motion and range from horizontal motion.

4. Imagine firing a gun horizontally across an open, flat plain. At the same instant that the bullet leaves the barrel, the empty shell casing is ejected horizontally from the gun.
Which hits the ground first, the bullet or the casing? Explain.
They land at the same time, (assuming same vert. distance) but of course they land far apart horizontally. All masses fall vertically at the same rate, regardless of their horizontal motion.

Suggested Answers Discusssion / Activity 2

Circular Motion

1. For an object in circular motion, in what direction is the:

a) instantaneous velocity? At a tangent to the circle.

b) centripital acceleration? Towards the centre of the circle.

c) centripital force? Towards the centre of the circle.

2. Explain how an object in circular motion can be described as having a constant speed, but also a constant acceleration? Isn't this a contradiction?

Acceleration means any change in speed OR in direction. Although the speed (in ms^{-1}) is constant, its direction is constantly changing. In vector terms this is a change in velocity & therefore acceleration.

3. Derive from first principles, a mathematical expression for:

a) the orbital speed.

For one revolution, the distance covered is circumference. ie $2\pi r$. The time taken is the period "T".

So, the orbital speed $v = 2\pi r / T$

b) the angular velocity. There are 2π radians of angle in one revolution. Revolution time = T.

So, angular velocity $\omega = 2\pi / T$

c) Combine these 2 expressions to form a formula showing how orbital speed and angular velocity are related.

$v = 2\pi r / T$ but $\omega = 2\pi / T$. Therefore, by substitution $v = \omega . r$

4. What force provides the centripital acceleration in the case of:

a) an orbiting satellite? Gravity

b) a car turning a corner? Friction between tyres & road

c) a ball being twirled on a string? Tension force in the string keep it simple science

Suggested Answers Discusssion / Activity 3

Motion in Gravitational Fields

1. a) Given that the gravitational force on a mass (which is in a grav. field) is equal to the objects weight force at that point, derive an expression for "g", the acceleration due to gravity.

Weight force = Grav.Force, so $mg = GMm / r^2$. Simplifying gives $g = GM / r^2$

b) Arising from (a) comes another way to interpret the meaning of "g". Give an outline of this meaning.

As well as being the "acceleration due to gravity" in ms^{-2}, "g" can be considered as the strength of the magnetic field (in $N.kg^{-1}$), measured as the force on a "test mass" of 1kg.

2. Two important types of satellite orbits can be described as "geostationary" and "polar low-Earth". For each, describe the main features of each orbit and relate these features an an appropriate technological use of a satellite in such an orbit.

A geostationary orbit is above the equator, with an orbital period = 1 day. This means that the satellite appears to stay in exactly the same point in the sky. This makes it ideal for communications because transmission dishes can be permanently aimed at it. A low, polar orbit passes (roughly) over north & south poles. It is a much faster orbit and closer to the surface, so ideal for weather observations, photo surveys, etc. It only "sees" a narrow stripe of Earth, but each orbit can study a different stripe. Eventually the entire surface can be observed.

3. a) What was Kepler's "Law of Periods" about?

It describes the relationship between the radius & period of a satellite, originally discovered for the planets orbiting the Sun.

b) Write a simple mathematical expression to summarise this law. $r^3 / T^2 = \text{constant}$

c) Outline Newton's proof of the law.

Starting from the proposition that gravitational force was providing the centripital force of the orbit, he was able to mathematically derive Kepler's law.

d) What was the significance of this proof in the history of Science?

This established gravity as a universal force while also giving mathematical proof to Kepler's empirically derived law. It basically proved the "heliocentric" idea & destroyed the ancient geocentric belief. Combined with telescopic observations, it marks the beginnings of modern Science. (in the opinion of many)

4. Why is the value of an object's gravitational potential energy always a negative quantity?

It arises because of the formal definition of grav.potential energy as being zero at infinite distance away. Since GPE must decrease at closer distances, it must always be negative.