Mechanics & Relativity

Dr Lily Asquith (Lily)

Week 3

Submit your workshop problem (vectors) for marking by noon Friday

Y1 : UPDATED MARK SCHEME FOR M&R AND MM1

0 Nothing submitted
1 Some work submitted but incomplete or no working shown
2 A correct answer reached but room for improvement in layout or approach
3 Well explained algebraic solution and correct answer

From this week on (vectors problem) to get 3/3 you will have to use the right number of sig figs, units, and some words to explain any assumptions or conclusions you reach.

The deadline for submission is Friday before 12 noon. If you have a really good reason for delaying your studies, please email your lecturers in advance of the deadline so we can liaise with your Doctoral Tutor

Examples showing the difference between 2/3 and 3/3 on next slides!

UNIVERSITY OF SUSSEX

Submit your workshop problem (vectors) for marking by noon Friday

Example of getting the right number of sig figs

$$\underline{a} = \underbrace{3.219}\,m\,\hat{i} + \underbrace{6.400}\,m\,\hat{j} + \underbrace{0.1010}\,m\,\hat{k}$$

The components all have 4SF

$$\underline{b} = \underbrace{0.010}_{2\,SF}\,\hat{i} + \underbrace{0.01}_{1\,SF}\,\hat{j} + \underbrace{10.010}_{5\,SF}\,\hat{k}$$

$$\underline{a}\cdot\underline{b} = a_x b_x + a_y b_y + a_z b_z$$

$$= \underbrace{(3.219)(0.010)} + (6.400)(0.01) + (0.1010)(10.010)$$

Calculator gives 0.0321899...... don't write this down.
STORE IT (full precision) in your calculator

$\underline{a}\cdot\underline{b} = 1.1072$. (full precision)

$= 1$ [1SF : the lowest precision from inputs]

Submit your workshop problem (vectors) for marking by noon Friday

Example of being fully on top of units

$KE_e = 2000\ \text{eV}$: 4SF

$m_e = 511\ \text{keV}/c^2$: 3SF

What is the velocity of the electrons?

$$KE = \frac{1}{2}mv^2 \quad \therefore \quad v = \sqrt{\frac{2\,KE}{m}} = \sqrt{\frac{2 \times 2 \times 10^3\ \text{eV}}{5.11 \times 10^5\ \text{eV}/c^2}}$$

$$\boxed{v = 0.0885c\ [3SF]}$$

This is correct as you have left in units of "c", which is fine

Now, if you decide to give your answer in units of ms^{-1}:

$$v = \sqrt{\frac{2 \times 2 \times 10^3\ \text{eV}}{5.11 \times 10^5\ \text{eV}}\, c^2}$$

use full precision value for c

$$\boxed{v = 2.65 \times 10^7\ ms^{-1}\ [3SF]}$$

UNITS

ALSO CORRECT

UNIVERSITY OF SUSSEX

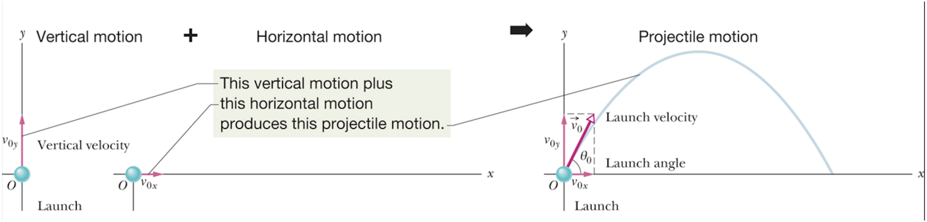
Vectors

This week's topics:

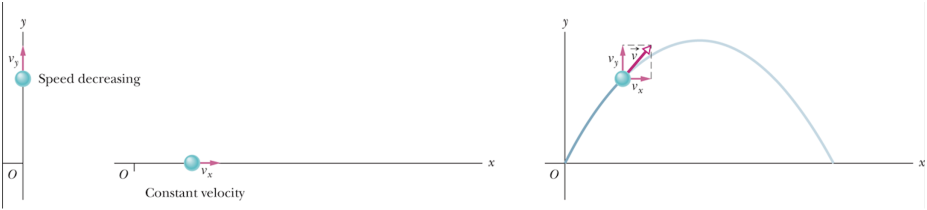
A problem in the vertical plane

Projectiles are “2D” problems; but we can split them into two “1D” problems.

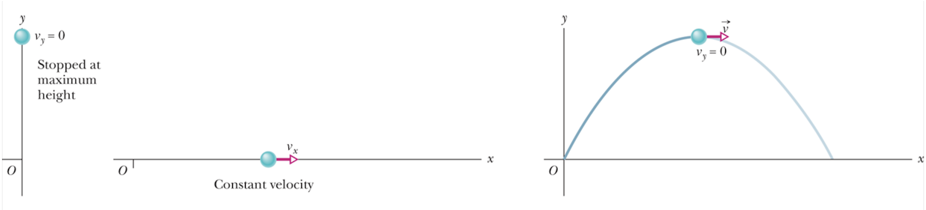
Projectile Motion



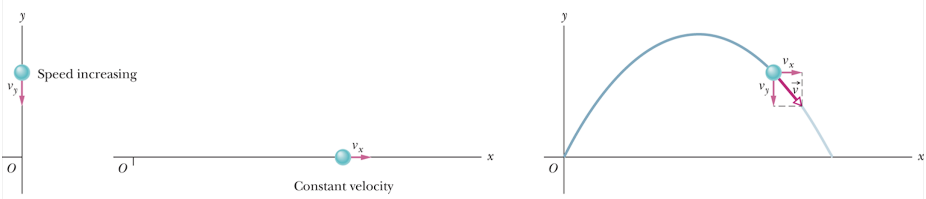
Projectile Motion



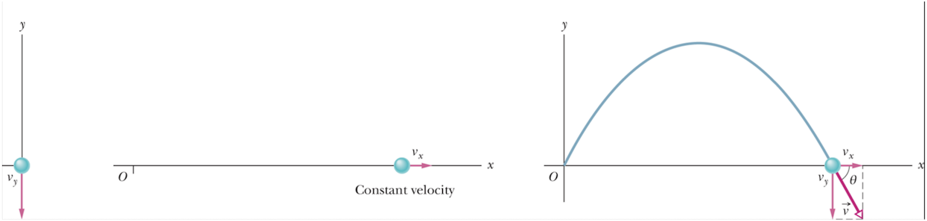
Projectile Motion



Projectile Motion



Projectile Motion



Divide and Conquer

$$s = ut + \frac{1}{2}at^2$$

Horizontal Motion

Vertical Motion

Example: ball rolling off a cliff

A small ball rolls horizontally off the edge of a tabletop that is 1.20 m high. It strikes the floor at a point 1.52 m horizontally from the table edge.

(a) How long is the ball in the air?

(b) What is its speed at the instant it leaves the table?

UNIVERSITY OF SUSSEX

The Path of a Projectile

The path is described like $y(x)$: want to eliminate t

Horizontal Range

At its maximum range, the vertical displacement of a projectile is zero.*

Vertical range

At its maximum height, the vertical speed of a projectile is zero.

Unpopular Adaptive Practice Problems

A particle's equation of motion is
$\vec{r}$ = [3 m + (4 m/s) t - (9 m/s^2) t^2+ (3 m/s^3) t^3] $\hat{i}$ + [6 m - (4 m/s) t + (2 m/s^2) t^2 - (5 m/s^3) t^3] $\hat{j}$.
At what time is the x-component of the velocity a minimum?

Unpopular Adaptive Practice Problems

From a height of 2 m, a ball is thrown towards a wall that it is 6 m away. Its initial velocity is 15 m/s at an angle of 30° to the horizontal. The ball will hit the wall at a certain height from the floor. Calculating for the effect of gravity, how much lower on t wall will the ball hit than when calculating neglecting the effect of gravity?

- 2.00 m
- 3.46 m
- 1.04 m
- 2.42 m
- 0.86 m

UNIVERSITY OF SUSSEX

Uniform Circular Motion

Some thoughts on the Centripetal Force

Everything moves in a straight line at constant velocity, unless a force is present.

Circles: $s = r\theta$

Circumference:

Radius:

Angle of one full rotation:

Arc length on circumference:

Angular Variables

The Chain Rule: $\frac{du}{dt} = \frac{du}{d\theta}\frac{d\theta}{dt}$

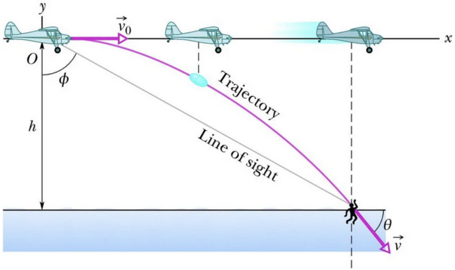
The radius r is constant for a circle, but the radius vector $\underline{\mathrm{r}}$ is changing with time.

Circles: r is constant, but $\underline{r}$ is changing!

The Acceleration(s)

Problem: plane dropping load

A rescue plane flies at $v = 55.0$ ms^{-1} and constant height $h = 500$ m toward a point directly over a victim, where a rescue capsule is to land. What should be the angle ϕ of the pilot's line of sight to the victim when the capsule release is made?



Problem: astronaut in a centrifuge

•**22** An astronaut is tested in a centrifuge with radius 10 m and rotating according to $\theta = 0.30t^2$. At $t = 5.0$ s, what are the magnitudes of the (a) angular velocity, (b) linear velocity, (c) tangential acceleration, and (d) radial acceleration?

Problem: satellite in orbit

•**56** An Earth satellite moves in a circular orbit 640 km (uniform circular motion) above Earth's surface with a period of 98.0 min. What are (a) the speed and (b) the magnitude of the centripetal acceleration of the satellite?

UNIVERSITY OF SUSSEX

Problem: killer projectile problem