

INTRODUCTION

ANGLES, CIRCLES & SPHERES

- Angle in *radians* = Pathlength along circular segment / Radius
- Circumference = $2\pi R \rightarrow 2\pi$ *radians* = 360° and 1 *radian* = 57.3°

Volume of a sphere:	$(4/3)\pi R^3$	Area of a circle:	πR^2
Surface of a sphere:	$4\pi R^2$	Circumference of a circle:	$2\pi R$

MEASUREMENTS & UNITS

- Most physical quantities consist of a *number* and a *unit*. They belong together. When a quantity depends on a unit it has a *dimension*.
- The measured value of a quantity has an uncertainty which corresponds to the accuracy of the measurement. This uncertainty determines how many digits or *significant figures* are stated for the value. When you modify equations always round to the smallest number of significant figures present in the equation.
- The units express the dimension of the quantity. When you modify equations keep the units with the numbers and treat them like numbers (for example: $1m^2 = (100cm)^2 = 100^2cm^2 = 10000cm^2$). The units of your final equations must be correct, otherwise your equation is wrong, for example if you derived a time your units must be seconds, minutes or hours etc.)
- Unit Conversion: Multiply the unit with a value that is equal to 1: (for example to convert from cm into m: $1m/100cm$)

SCALARS & VECTORS

- *Scalars* are quantities which specify only magnitude. *Vectors* are quantities which have magnitude and direction.
- The magnitude or size of a vector is always a positive number.
- Vectors can be expressed in two ways, and for both you need two quantities to specify the vector:
 - (i) Length and angle, where normally the angle is measured counterclockwise from the positive x-axis.
 - (ii) The two components of the vector along the x and y axes. These components have a direction along the positive or negative direction compared to the axis.

Transform from (i) to (ii): $A_x = A\cos\theta$ and $A_y = A\sin\theta$

Transform from (ii) to (i): $A = \sqrt{A_x^2 + A_y^2}$ and $\tan\theta = A_y/A_x$

If you measure θ as the positive angle from the x-axis independent of the quadrant, then the equations will yield only the magnitude of the components and you have to read the directions from the table. When you calculate θ from the components, use only the magnitude from the equation and determine the direction from the signs of the components.

Quadrant	x	y
upper right	+	+
upper left	-	+
lower left	-	-
lower right	+	-

- Vectors are added (subtracted) by adding (subtracting) the x and y components independently: $\vec{C} = \vec{A} + \vec{B}$ means $C_x = A_x + B_x$ and $C_y = A_y + B_y$.

VELOCITY AND ACCELERATION I

VELOCITY IN ONE DIMENSION

- Average Speed (scalar): total distance traveled/ time interval for travel
- Average Velocity (vector): (final position - initial position)/(final time - initial time)
 $v = (x_f - x_i)/(t_f - t_i) = \Delta x/\Delta t$
- Instantaneous Velocity (vector): $v = \Delta x/\Delta t$, where the change Δ corresponds to an interval shortly before to shortly after the point where the instantaneous velocity is determined.
- Careful: When you have an initial and final position and calculate the velocity it is the average velocity. This corresponds to the instantaneous velocity at the final position only when the acceleration is zero (see later)!!
- Graphical Interpretation (average velocity): The slope of the line connecting the initial and final positions in a position - time diagram.
- Graphical Interpretation (instantaneous velocity): The slope of the tangent to the curve in a position - time diagram.
- (Instantaneous) Speed (scalar): The magnitude or size of the instantaneous velocity (Remember: the magnitude or size of a quantity is always positive).
- The unit for speed and velocity is *meters/second* = m/s

ACCELERATION

- The acceleration (vector) is defined as:
 $a = (v_f - v_i)/(t_f - t_i) = \Delta v/\Delta t$.
- Graphical interpretation: The slope of the tangent to the curve in a velocity - time diagram. For constant acceleration this curve is a straight line. Thus, the acceleration is the slope of this line.
- The unit for acceleration is *meters/second²* = m/s^2

RELATIVE VELOCITY

- If an object A travels with a velocity v_{AB} with respect to object B , and B travels with v_{BC} with respect to an object C , then the velocity of A with respect to C is given by $\vec{v}_{AC} = \vec{v}_{AB} + \vec{v}_{BC}$. All the velocities are vectors!!
- Careful when drawing the velocity vectors. Do not confuse them with a position diagram.