Summary of Lecture 2 – KINEMATICS I

1. *x(t)* is called displacement and it denotes the position of a body at time. If the displacement is positive then that body is to the right of the chosen origin and if negative, then it is to the left.

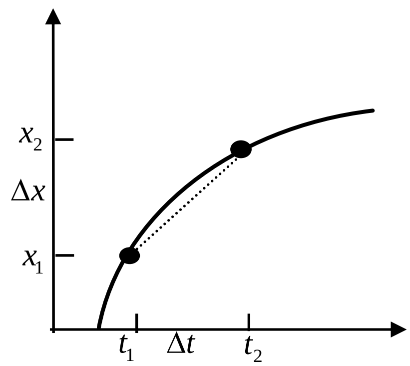
2. If a body is moving with average speed v then in time t it will cover a distance d=vt. But, in fact, the speed of a car changes from time to time and so one should limit the use of this formula to small time differences only. So, more accurately, one defines an average speed over the small time interval Δt as:

$$\text{average speed } = \frac{\text{distance travelled in time } \Delta t}{\Delta t}$$

3. We define *instantaneous velocity* at any time t as:

$$\mathrm{v} = \frac{x(t_2) - x(t_1)}{t_2 - t_1} \equiv \frac{\Delta x}{\Delta t} \quad .$$

Here Δx and Δt are both very small quantities that tend to zero but their ratio v does not.



4. Just as we have defined velocity as the rate of change of distance, similarly we can define *instantaneous acceleration* at any time t as:

$$a = \frac{\mathrm{v}(t_2) - \mathrm{v}(t_1)}{t_2 - t_1} \equiv \frac{\Delta \mathrm{v}}{\Delta t} \quad .$$

Here Δv and Δt are both very small quantities that tend to zero but their ratio a is not zero, in general. Negative acceleration is called deceleration. The speed of a decelerating body decreases with time.

5. Some students are puzzled by the fact that a body can have a very large acceleration but can be standing still at a given time. In fact, it can be moving in the opposite direction to its acceleration. There is actually nothing strange here because position,

6. For constant acceleration and a body that starts from rest at $t = 0$, v increases linearly with time, $\mathrm{v} \propto t$ (or $\mathrm{v} = at$). If the body has speed v_0 at $t = 0$, then at time t, $\mathrm{v} = at + \mathrm{v}_0$.
7. We know in (6) above how far a body moving at constant speed moves in time t. But what if the body is changing its speed? If the speed is increasing linearly (i.e. constant acceleration), then the answer is particularly simple: just use the same formula as in (6) but use the average speed: $(\mathrm{v}_0 + \mathrm{v}_0 + at)/2$. So we get $x = x_0 + (\mathrm{v}_0 + \mathrm{v}_0 + at)t/2 = x_0 + \mathrm{v}_0 t + \frac{1}{2}at^2$. This formula tells you how far a body moves in time t if it moves with constant acceleration a, and if started at position x_0 at $t=0$ with speed v_0.

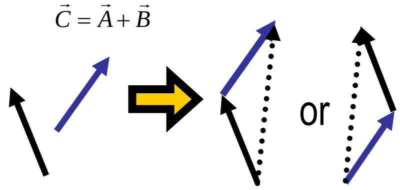
8. We can eliminate the time using (7), and arrive at another useful formula that tells us what the final speed will be after the body has traveled a distance equal to $x - x_0$ after time t, $\mathrm{v}^2 = \mathrm{v}_0^2 + 2a(x - x_0)$.

9. Vectors: a quantity that has a size as well as direction is called a *vector*. So, for example, the wind blows with some speed and in some direction. So the *wind velocity* is a vector.

10. If we choose axes, then a vector is fixed by its components along those axes. In one dimension, a vector has only one component (call it the x-component). In two dimensions, a vector has both x and y components. In three dimensions, the components are along the x,y,z axes.

11. If we denote a vector $\vec{r} = (x, y)$ then, $r_x = x = r\cos\theta$, and $r_y = y = r\sin\theta$. Note that $x^2 + y^2 = r^2$. Also, that $\tan\theta = y/x$.

13. Two vectors can be added together geometrically. We take any one vector, move it without changing its direction so that both vectors start from the same point, and then make a parallelogram. The diagonal of the parallelogram is the resultant.



14. Two vectors can also be added algebraically. In this case, we simply add the components of the two vectors along each axis separately. So, for example, Two vectors can be put together as $(1.5, 2.4) + (1, -1) = (2.5, 1.4)$.