PY1007: Physics for Engineers I

LECTURES: Kane Building G1

TUESDAY	THURSDAY
12 - 13	13 - 14

Lecturers

Dr. Richard Green
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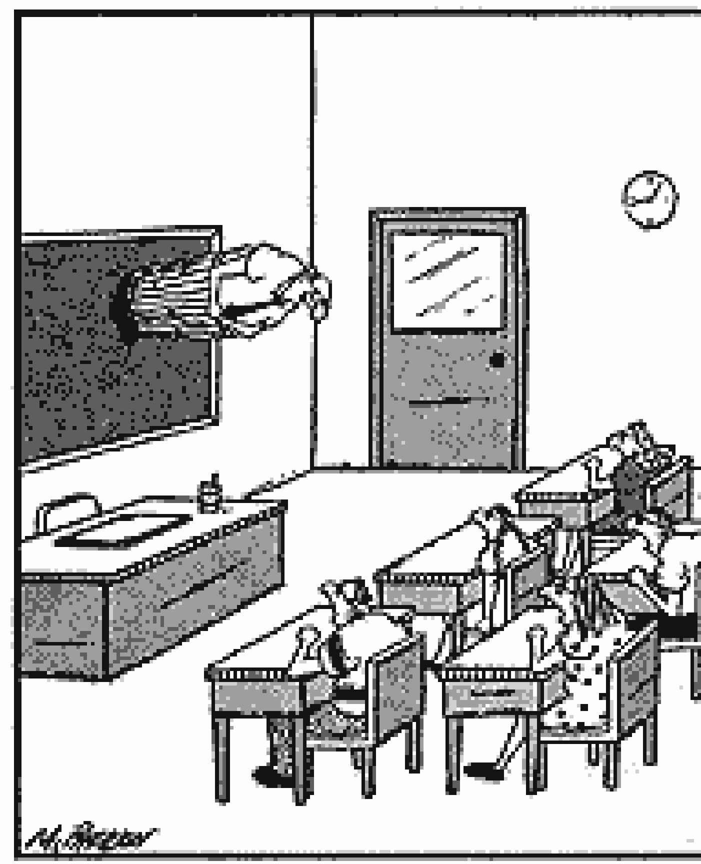
1st Floor, Kane (Science) Building

Dr. Síle Nic Chormaic (**Module Coordinator**)
Direct all queries to: s.nicchormaic@ucc.ie
Room 216a, 2nd Floor, Kane (Science) Building

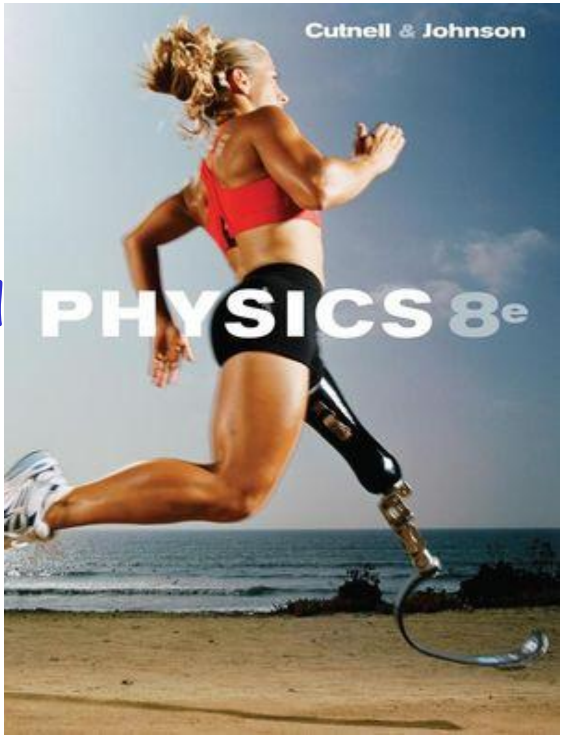


"Good morning, and welcome to The Wonders of Physics."

RECOMMENDED TEXTBOOKS

Physics by Cutnell and Wiley
Publisher: John Wiley & Sons

Paper version available to buy in the college book shop in Áras na Mac Léinn. Strongly Recommended



College of SEFS will cover the purchase of the electronic version of this book. This will provide you with a host of study aids for the course. Will be the main source of information, problem sets etc.

Copies of book are also in the college library or second-hand copies may be available from second year students.

If you BUY the book (new or second hand) please inform me by email at s.nicchormaic@ucc.ie

Weekly Homework Assignments

These will be done **electronically** at: www.wileyplus.com the electronic book we are using. You will need PC access!!! Lectures from week 3 will be posted here also and no longer on my website.

http://www.physics.ucc.ie/nicchormaic/Teaching.html

I need to set you up on the system – student ID number, email address, name needed ASAP so that you can login and access the homework. When I have set you up you will get an email. If you don't get this email come talk to me – it means I couldn't read your writing!!!

This will also give you access to electronic book Cutnell & Johnson ☺ Also access to video resources etc.

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Physics for Engineers

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Hello **SILE NIC CHORMAIC**, you are logged into:

Physics for Engineers
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Instructor(s): Colm Kelleher, SILE NIC CHORMAIC

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WEB SUPPORT

Information on the Lectures, Lab Practicals, Helpdesk, Problem Sets, etc. will also be posted on the web:

http://www.physics.ucc.ie/nicchormaic/Teaching.html

or www.wileyplus.com from week 3 onwards only.

Please print a copy of notes before each lecture.

Once you have all registered on WileyPLUS all course details will be contained on that site instead of the Teaching.html site.

Laboratory: Commence week of 4th October

Your lab group listing is posed on 1st Floor, Kane/Science building in front of elevators- check this ASAP. If your name is not on list please contact Mossey Crowe at m.crowe@ucc.ie to get assigned to a slot.

THINGS YOU MUST BRING TO LAB:

1) one laboratory instruction manual (you get this at lab)

3) pad of A4 size lined paper
4) pad of A4 sized graph paper

5) one standard A4 loose -leaf binder with two 8 cm binding clips (available from Student Centre bookshop)

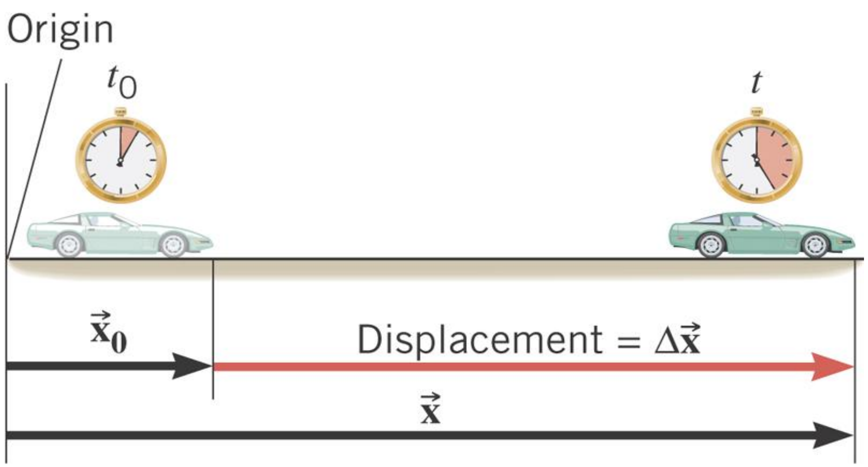
6) drawing instruments including pencil, eraser, transparent ruler, etc.

7) electronic pocket calculator

8) small stapler

Kinematics in 1D: Velocity (p28 C&J)

Last lecture we discussed *displacement* – a vector that points from an object's initial position ($\underline{x}_0$ at time t_0) to its final position ($\underline{x}$ at time t). The magnitude of displacement is the shortest distance between the two positions.



$$\Delta \underline{x} = \underline{x} - \underline{x}_0 \equiv \vec{x} - \vec{x}_0 = \Delta\vec{x}$$

Δ (delta) indicates a change or a difference

We define *velocity*, $\underline{v}$, as the rate of change of the displacement vector.

$$\text{i.e. average velocity} = \frac{\text{displacement}}{\text{elapsed time}} \Rightarrow \underline{v} = \frac{\Delta\underline{x}}{t - t_0}$$

SI unit for velocity:

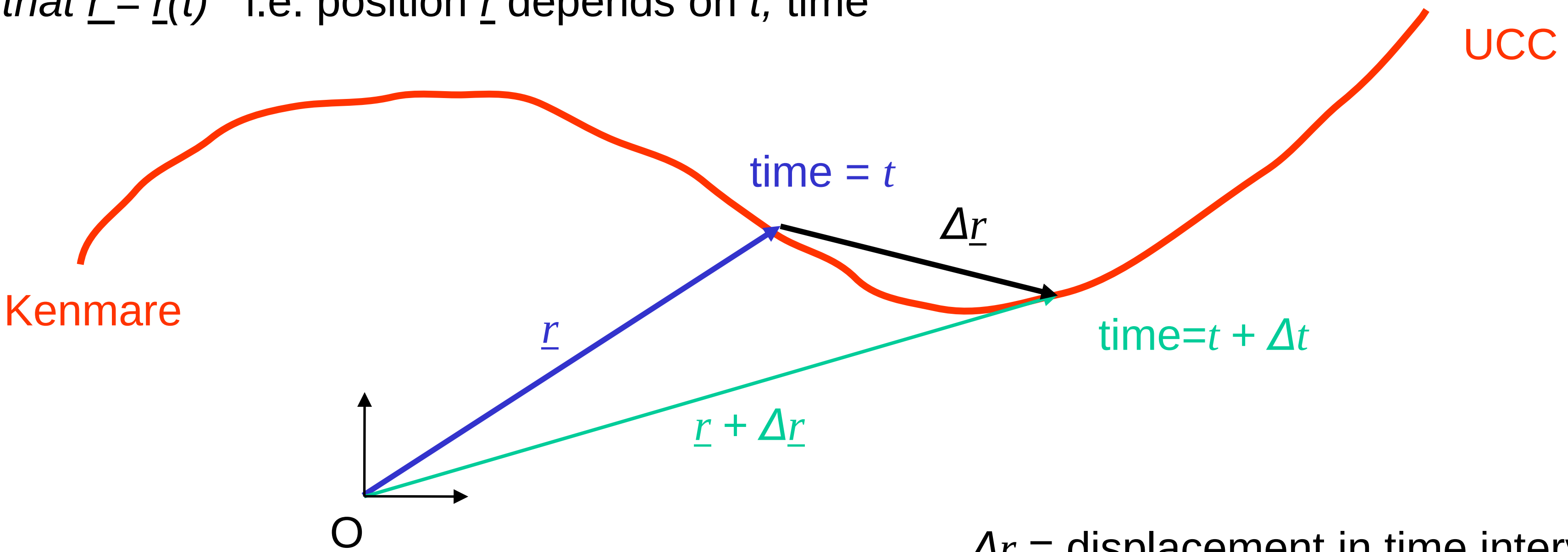
$$\frac{\text{Unit for displacement}}{\text{Unit for time}} = \frac{[L]}{[T]} = \frac{\text{meter}}{\text{second}} \equiv \text{ms}^{-1}$$

Velocity is a vector – we **must** define magnitude and direction

Velocity (in an arbitrary direction)

Let's consider journey from Kenmare to UCC. At any time t, your position is defined by some position vector, $\underline{r}$. Your position at some later time $t + \Delta t$ is defined by a new position vector $\underline{r} + \Delta\underline{r}$.

Note that $\underline{r} = \underline{r}(t)$ i.e. position $\underline{r}$ depends on *t,* time



$\Delta\underline{r}$ = displacement in time interval Δt

Definition: **Velocity,** $\underline{v}$, of a point relative to the origin, O (from previous slide):

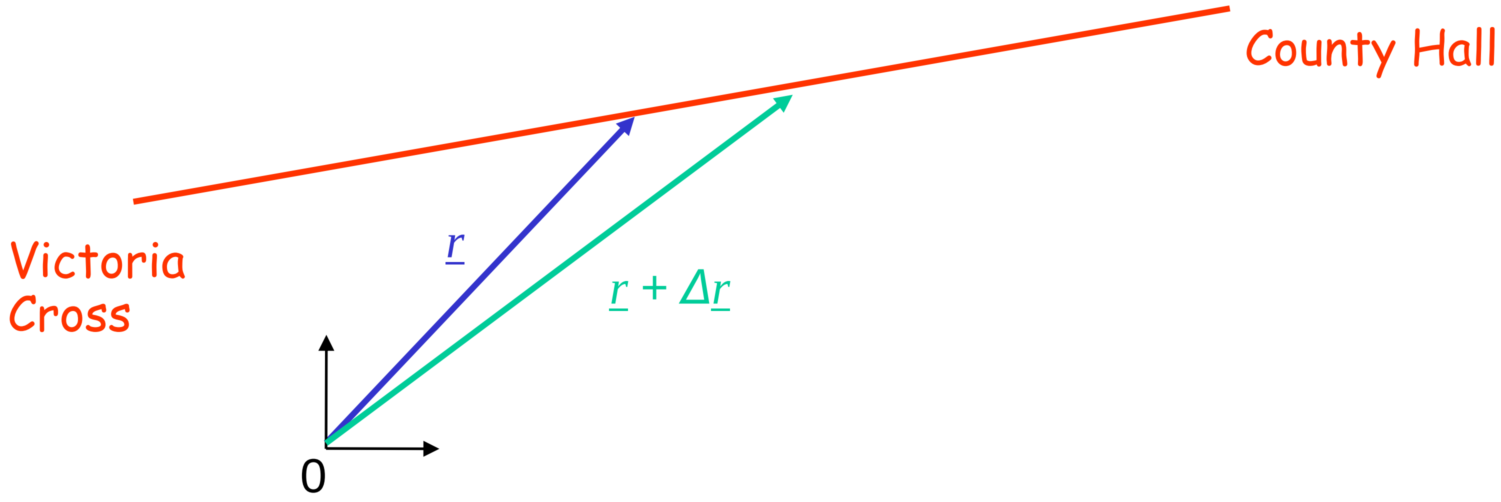
$$\underline{v} = lim_{\Delta t \to 0} \frac{\Delta \underline{r}}{\Delta t} = \frac{d\underline{r}}{dt}$$

Velocity is the rate of change of position with respect to time.

The direction of $\underline{v}$ is parallel to $\Delta\underline{r}$ in the limit of $\Delta t \to 0$ (i.e. very short time intervals).

Constant Velocity

Consider the special case of constant velocity $\underline{v} = \underline{V}$ ⟶ i.e. straight line of motion (constant direction and magnitude)



How does the displacement $\underline{r}$ depend on time in this case?

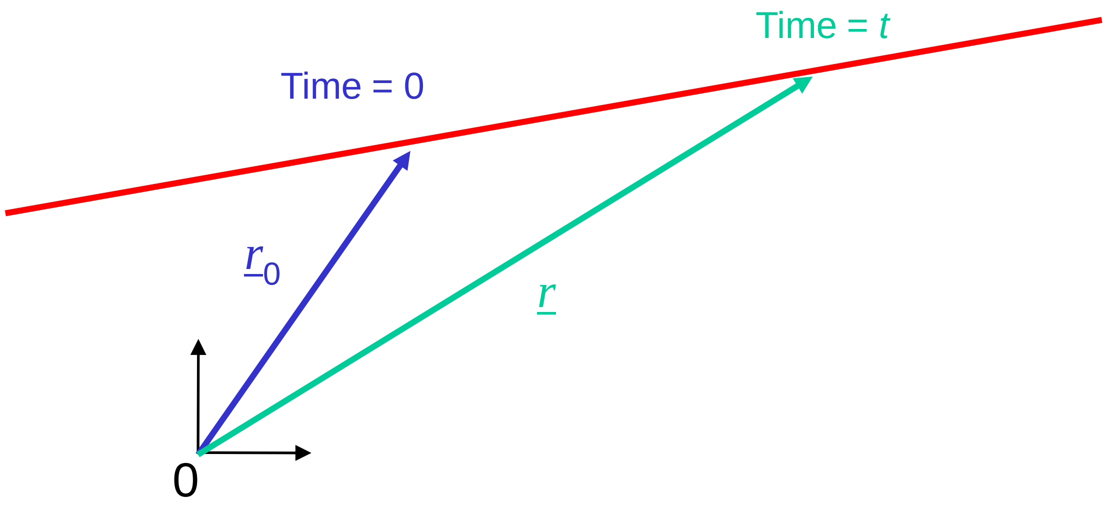
$$\frac{d\underline{r}}{dt} = \underline{V} = constant$$

On integration over time, t. $\Rightarrow$

$$\underline{r} = \underline{V}t + \underline{c}$$

$\underline{c}$ is a constant vector arising from the integration – we need to determine what it represents physically.

Constant Velocity

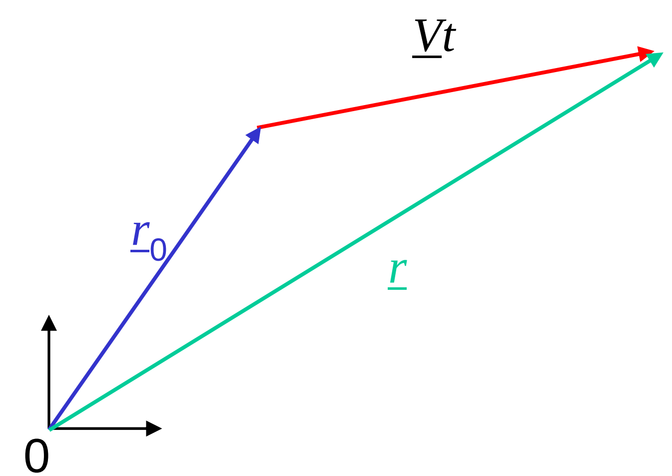


Choose the origin of time such that $\underline{r} = \underline{r}_0$ when $t = 0$.

$$\Rightarrow \qquad \underline{r}_0 = (\underline{V})(0) + \underline{c}$$

$$\Rightarrow \qquad \underline{c} = \underline{r}_0$$

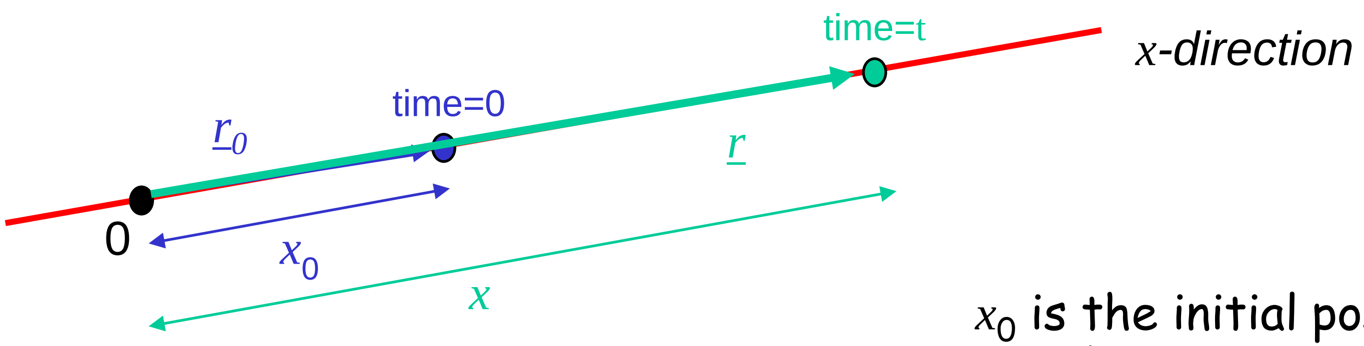
$$\underline{r} = \underline{V}t + \underline{r}_0$$



Vector addition

Constant Velocity

For simplicity, choose the origin 0 on the line of travel:



x_0 is the initial position
x is the position after time, t

Definition: Let $\underline{i}$ be a unit vector in the x-direction (points along x with length 1)

$$\underline{r}_0 = x_0\,\underline{i}$$
$$\underline{r} = x\,\underline{i}$$
$$\underline{V} = V\,\underline{i}$$

$\longrightarrow$

$$\underline{r} = \underline{V}t + \underline{r}_0$$
$$x\,\underline{i} = V\underline{i}t + x_0\,\underline{i}$$
$$x = Vt + x_0$$

We now have an algebraic relationship between position, speed and elapsed time instead of a vector relationship.

Note: when dealing with algebraic quantities, three things have to be taken into account: sign, magnitude and unit

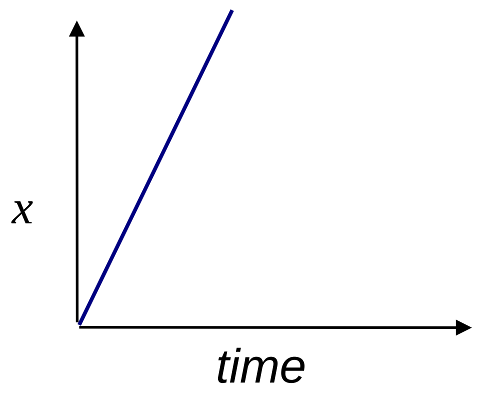
Constant Velocity

In other words: the displacement, $\Delta x = x - x_0 = V\,t$

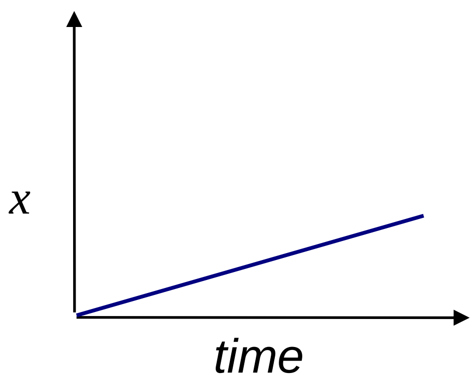
$\Delta x > 0 \quad \Rightarrow V > 0$ Object moving in $+x$ direction

$\Delta x < 0 \quad \Rightarrow V < 0$ Object moving in $-x$ direction

Note: The equation for travel at constant velocity is of the form $x = Vt + x_0$, which is the equation for a straight line, with slope V.

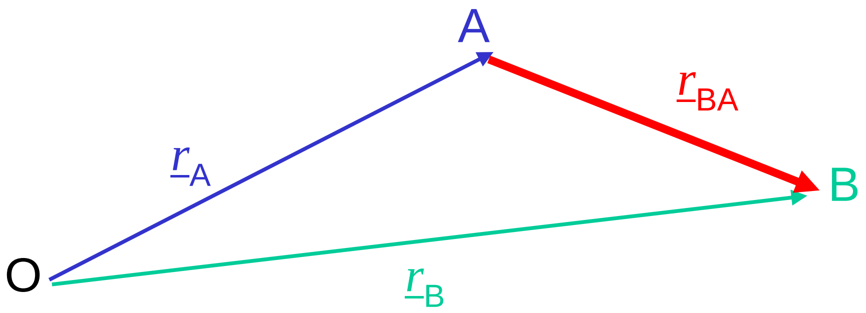


steep slope: velocity V is large



gentle slope: velocity V is small

Adding Velocities – add in the same way as for any vector

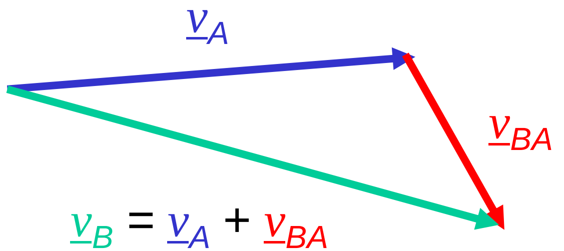


$\underline{r}_A$ = displacement of A relative to O
$\underline{r}_B$ = displacement of B relative to O
$\underline{r}_{BA}$ = displacement of B relative to A

$$\underline{r}_A + \underline{r}_{BA} = \underline{r}_B$$
$$\Rightarrow \underline{r}_{BA} = \underline{r}_B - \underline{r}_A$$

Take time derivatives
to determine velocities:

$$\frac{d\underline{r}_{BA}}{dt} = \frac{d\underline{r}_B}{dt} - \frac{d\underline{r}_A}{dt}$$
$$\Rightarrow \underline{v}_{BA} = \underline{v}_B - \underline{v}_A$$
$$\Rightarrow \underline{v}_A + \underline{v}_{BA} = \underline{v}_B$$

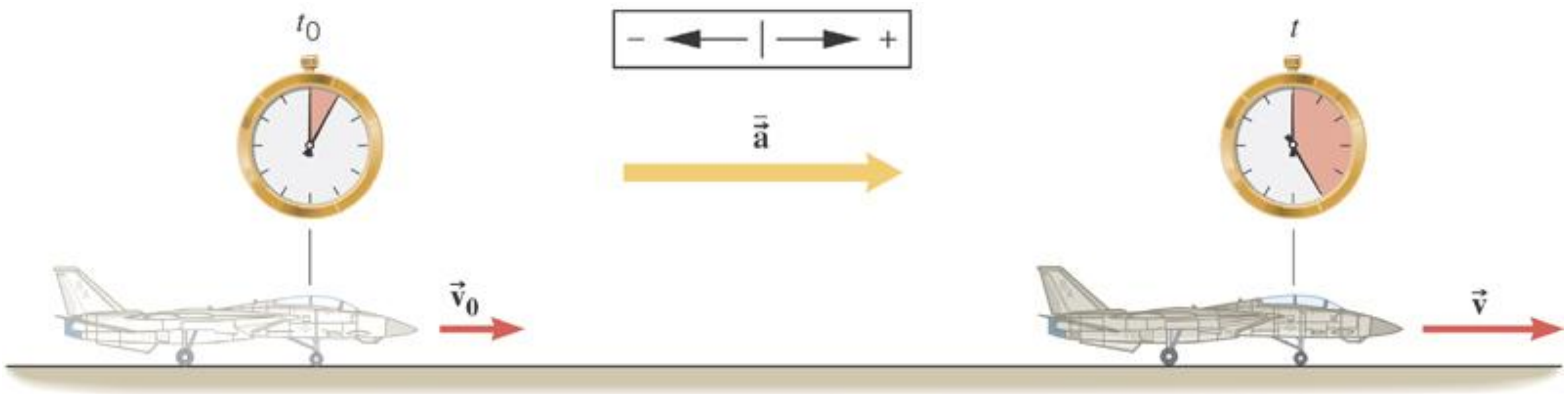


$\underline{v}_B = \underline{v}_A + \underline{v}_{BA}$

Acceleration – a vector with magnitude and direction

Velocity of moving object may change: e.g. velocity can increase or decrease if you push your foot on the "accelerator" or "brake" in a car.

This change can occur over short or long time interval.



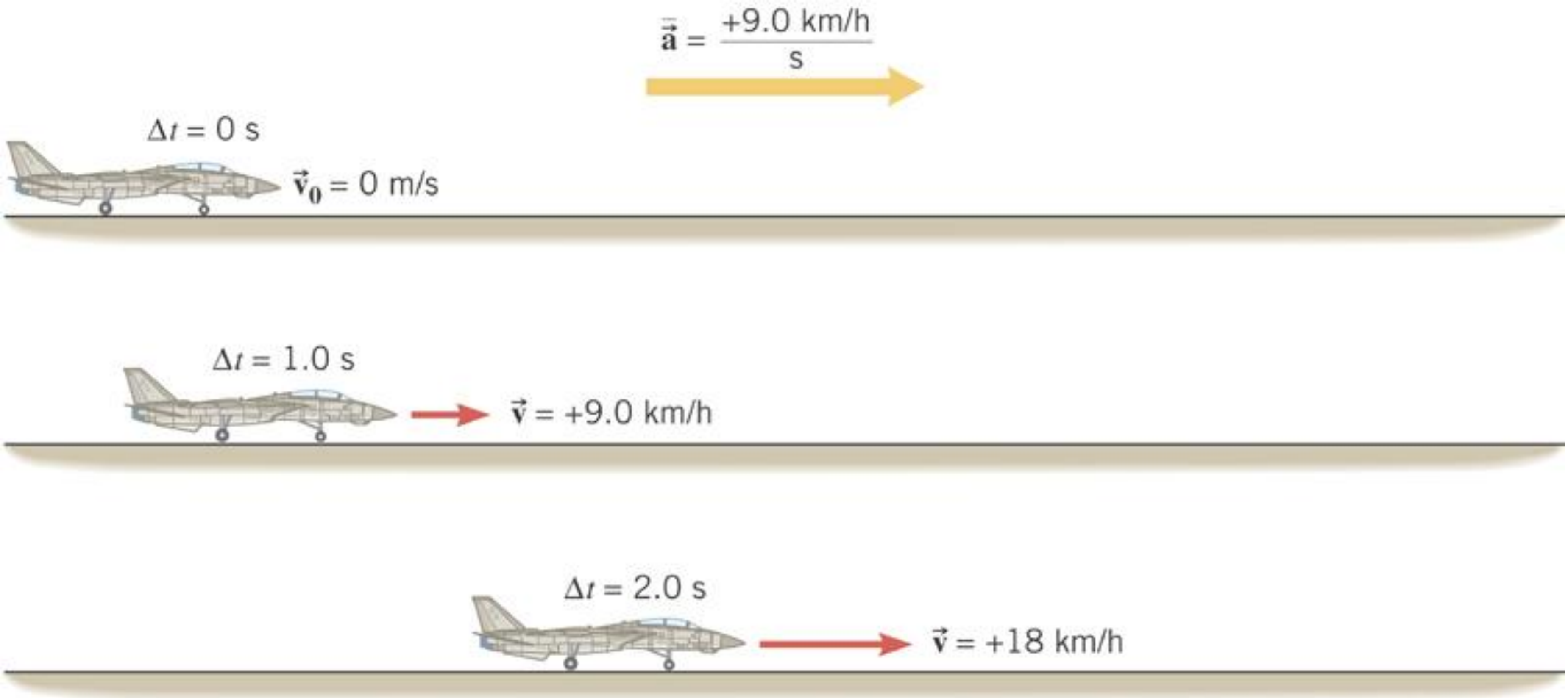
Acceleration, $\underline{a}$, describes rate of change of velocity i.e. change in velocity ($\Delta\underline{v} = \underline{v} - \underline{v}_0$) over particular time interval ($\Delta t = t - t_0$) . Acceleration is a vector quantity.

$$\text{i.e. average acceleration} = \frac{\text{change in velocity}}{\text{elapsed time}} \Rightarrow$$

$$\underline{a} = \frac{\underline{v} - \underline{v}_0}{t - t_0} = \frac{\Delta\underline{v}}{\Delta t}$$

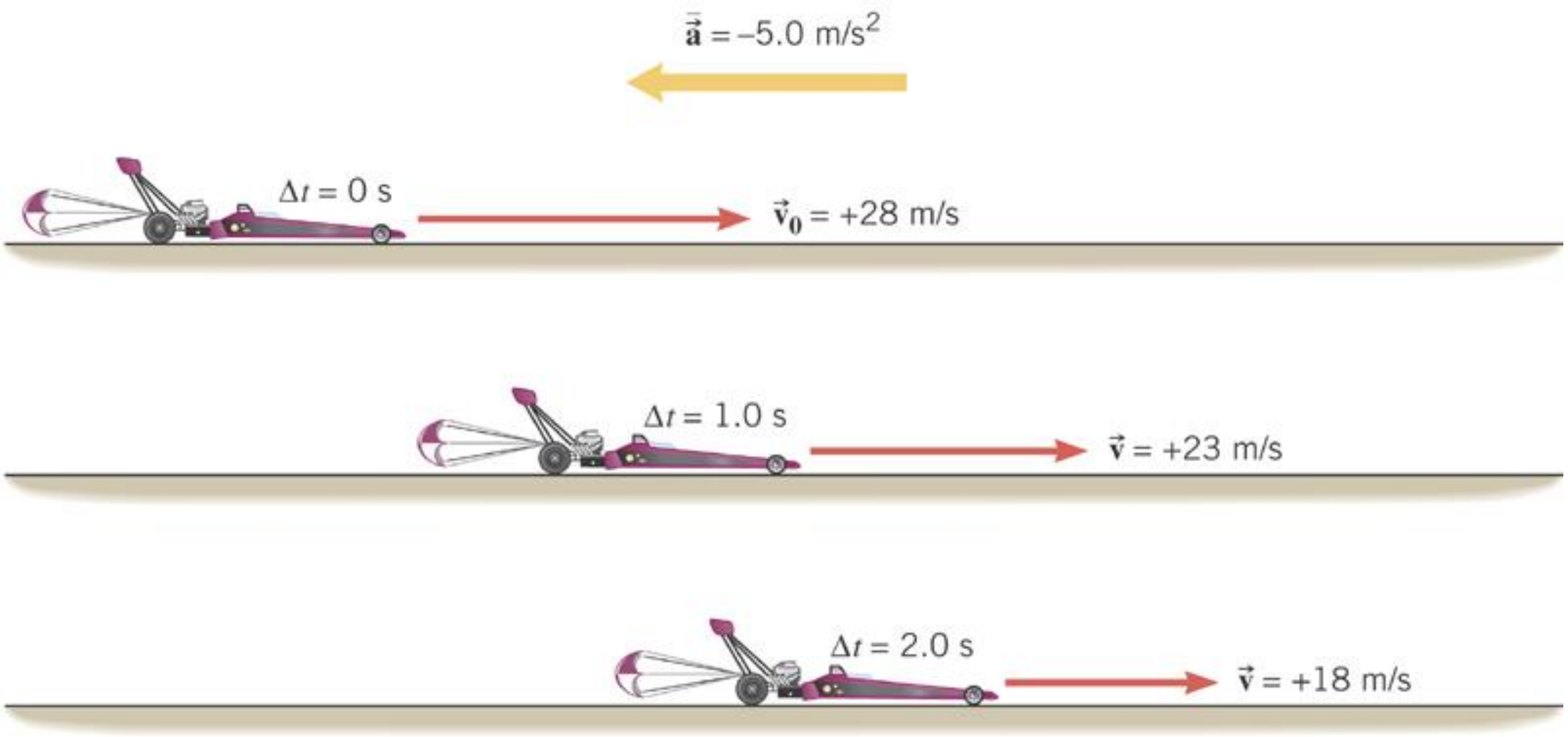
SI unit of acceleration: $\dfrac{\text{meter/second}}{\text{second}} \equiv \text{ms}^{-2}$

Acceleration



An acceleration of +9km/hour/second means that during each second the velocity of the plane will **increase** by 9km/hour.

Acceleration - deceleration



An acceleration of -5 ms^{-2} means that during each second the velocity of the car will **decrease** by 5ms^{-1}.

Note: Here the arrow for the direction of acceleration is opposite to that for velocity. The acceleration is negative, and the velocity therefore decreases.

Summary

We've extended the familiar equations of motion from the leaving certificate to the more realistic case where motion (position, velocity, acceleration) is described by vector quantities.

We have shown that acceleration, velocity and position are related through time derivatives.

$$\underline{v} = lim_{\Delta t \to 0} \frac{\Delta \underline{r}}{\Delta t} = \frac{d\underline{r}}{dt}$$

Velocity, vector quantity, units: ms^{-1}

$$\underline{a} = \lim_{\Delta t \to 0} \frac{\Delta \underline{v}}{\Delta t} = \frac{d\underline{v}}{dt}$$

Acceleration, vector quantity, units ms^{-2}