Introduction to Linear Kinematics

General information

This PowerPoint show contains 16 slides which provide:

- Definitions of Distance/Displacement, Speed/Velocity & Acceleration.
- An introduction to the use of vectors.

The slides on the use of vectors have been included as an understanding of vectors is essential at this stage. If vectors have been introduced elsewhere, you may choose to omit these slides.

Typically, you would draw from this pool of slides to create a single introductory lecture. However, you may wish to split the material into separate blocks.

There are a number of problems and calculations contained in the question bank drawing upon this material.

Slide 4

Illustrates the difference between distance and displacement. It is important to stress that distance as a scalar quantity has only a magnitude whereas to fully define a displacement, a vector quantity, both the magnitude and direction of the movement must be specified.
You may wish to illustrate this point with the following examples:

400 m race – Distance covered = 400 m, Displacement of the athlete = 0.
100 m race – Distance covered = 100 m, Displacement of the athlete = 100 m (in a specified direction).

Slide 5

Introduces Displacement and the concept of the vector. It shows how the magnitude and direction of displacement (or any vector quantity) can be represented by an arrow, drawn from the point of origin (in this case, the jumper's CM).

This slide also indicates the direction convention for vector quantities:
Movement to the right is positive (+ve), to the left it is negative (-ve).
Movement upwards is positive (+ve), downwards is negative (-ve).

In the example shown, the jumper's displacement has a +ve horizontal (green arrow) and a +ve vertical (blue arrow) component.

It is common in the analysis of human movement to measure horizontal and vertical motion separately, e.g. through the use of video digitizing. For example in a running race we are mainly concerned with the horizontal speed of the performer although they will also experience some vertical motion, whereas for a thrower we are interested in the combination of the horizontal and vertical motion i.e. the resultant motion.

Slide 6

Develops from the previous slide. It shows how two vectors (in this case the horizontal and vertical displacement of the jumper) can be combined using the Pythagorean Theorem to obtain a resultant vector (in this case the resultant displacement). It also shows trigonometry can be used to calculate the angle that the resultant vector makes to the horizontal.

You may wish to include some additional material on trigonometry (see online resources) here depending on the background of your students.

Slides 7-8

Illustrates the difference between speed and velocity. The terms are often used interchangeably but in biomechanics this is considered poor practice. It may be useful at this stage to clarify the difference between an average speed (or velocity) and an instantaneous speed (or velocity). In the example on slide 7, the Olympic Champion's average velocity was 10.15 $m \cdot s^{-1}$. However, there will be instants in the race where his velocity was higher and lower than this.

Slides 9-10

Show the time taken for a sprinter in a 100 m race to reach 10 m, 20 m, 30 m etc. The key point here is that there are different time periods which must indicate a different velocity. You might want to get the students to calculate the velocity using this data before you progress.

Slide 11

Shows how the sprinter's average velocity for each 10 m section of the race can be calculated. The concept of instantaneous velocity could be discussed using this slide by introducing the idea of calculating an average velocity over an extremely short displacement or time, e.g. 1 cm or 0.04 s.

Slide 12

Shows how a vector (in this case the jumper's resultant velocity) can resolved (broken down) using trigonometry to obtain its two components (in this case the horizontal and vertical components of the velocity).

Slide 13

Introduces acceleration. The methods of combining two vector components using Pythagorean Theorem (slide 6) and resolving (breaking down) a vector into its components using trigonometry (slide 12) can also be used when analyzing acceleration.

Slide 14

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Shows how an average acceleration can be calculated (using the information from slide 11). Note that although the runner maintains a velocity in the positive horizontal direction, it is possible for him to have a +ve, -ve or zero acceleration.