TRAINERMAKER

# The Mechanics of Sports Performance

Paul Bailey

# Introduction

To understand sport, we must first understand some basic principles and terminology. The following slides aim to give you an underpinning knowledge of the science behind human movement. The following slides contain key points which you should aim to understand and use.

Much of the following information is based on maths and physics. It is important for us to understand that in order for us to be the best sports conditioning practitioners, we must be able to apply this science in a meaningful way. The following slides therefore also include some examples of the application of the key terms, maths and physics.

# Speed

Speed is the rate of change of position. Speed does not specify direction of movement.

Speed = Distance / Time

In sport, speed is often measured as it is the defining feature of many sports performances.

The unit for speed is metres per second ($m/s^{-1}$)

Eg, 100m / 10s = $10m/s^{-1}$

# Velocity

Velocity is similar to speed – with the addition of ‘direction’ as a parameter. Due to this, the term ‘displacement’ is used instead of ‘distance’.

Velocity (V) = Displacement (s) / Time (t)

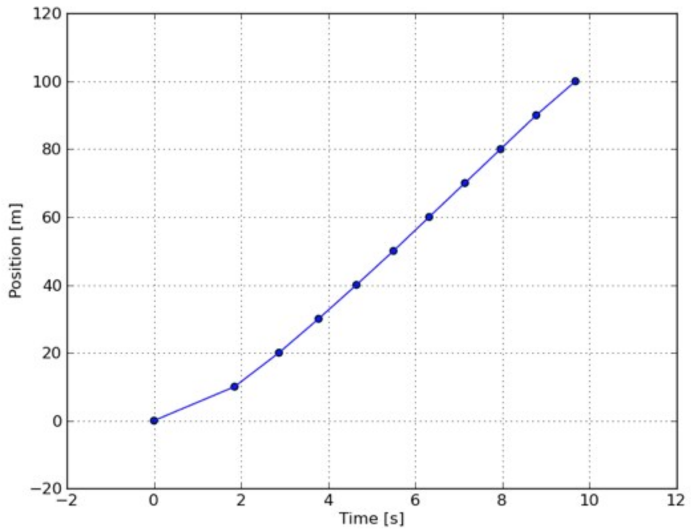
The term velocity is often is used when analysing sports performance as it gives a greater insight into movement than speed alone.

The unit for Velocity is $m/s^{-1}$

Eg, 1m / 0.1s = $10m/s^{-1}$

# Distance v time graph

It is often useful to represent movement in a graph format. Below is an example of  a distance v time graph for a 100m sprint.




In a distance v time graph, the angle of the line will represent the speed or velocity.

# Acceleration

Acceleration is the rate of change of velocity. Therefore it is specific to direction of movement.

Acceleration = $(V_f - V_i) / t$

Where: $V_f$ = final velocity, $V_i$ = initial velocity, t = time duration

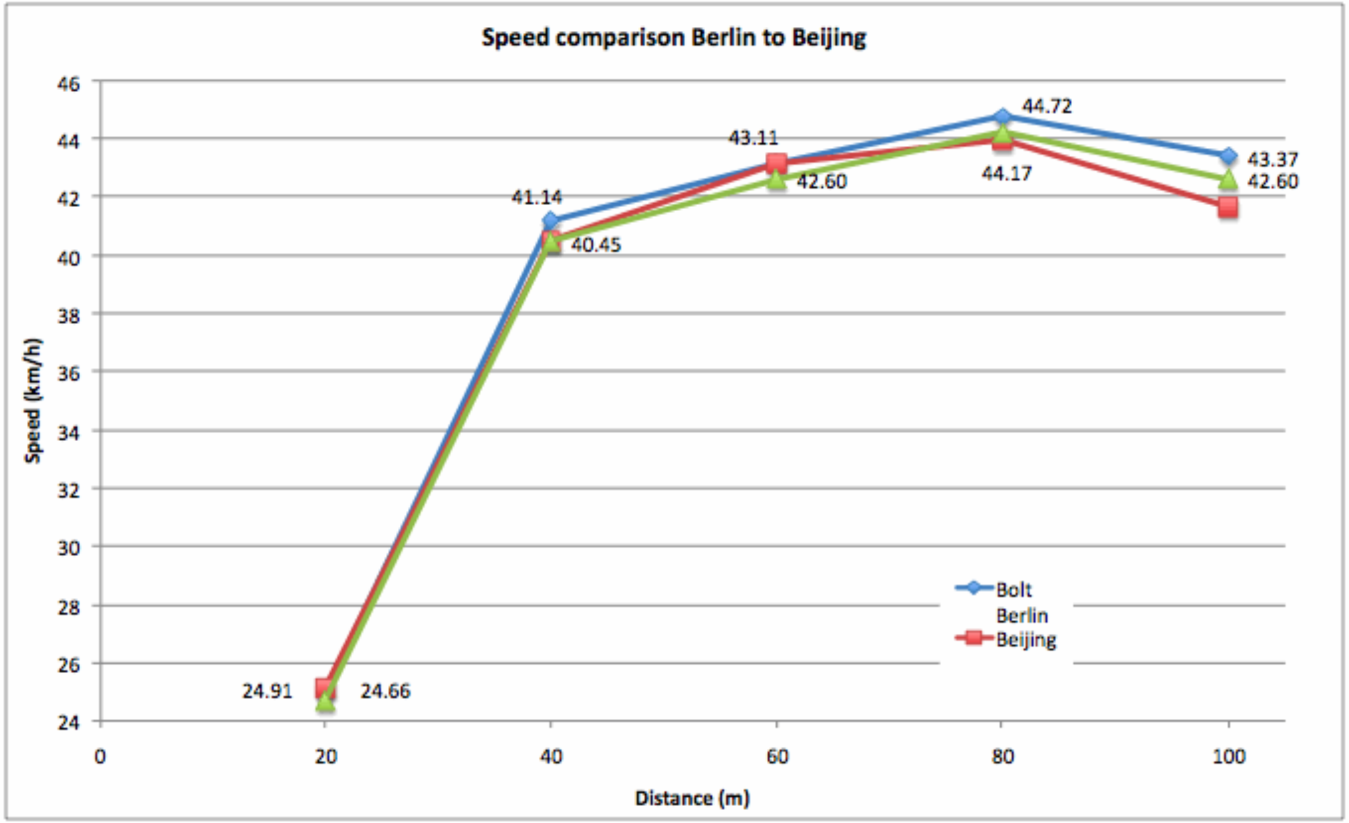
Acceleration is important. In sports that require speed of movement, it is often not the final speed that is a deciding factor in performance, but how quickly you get to that speed.

The unit for acceleration is $m/s^{-2}$

Eg, $5m/s^{-1} / 2s = 2/5m.s^{-2}$

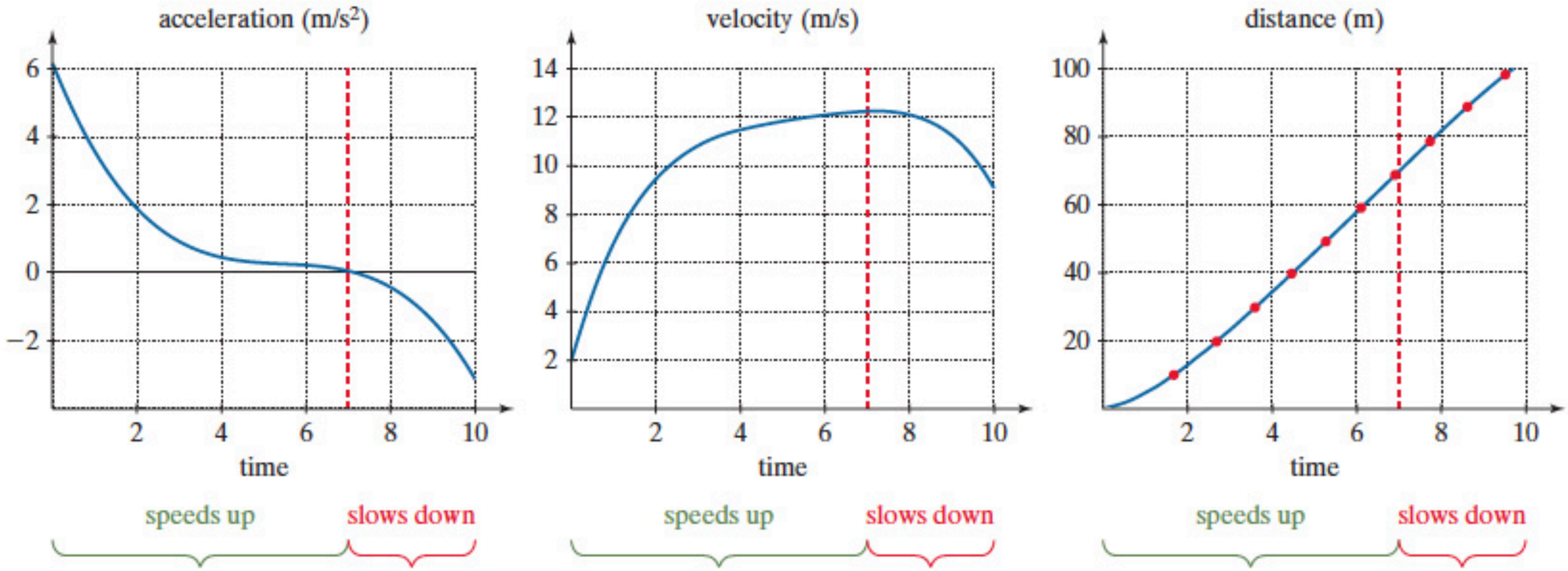
# Speed v time graph

Below is an example of  a speed v time graph for a 100m sprint (Bolt WR)



# Using graphs to analyse performance

Below is an example of how graphs can help understand a performance (Bolt WR)



# Scalar quantities

Scalar – a physical quantity that has magnitude (size) only

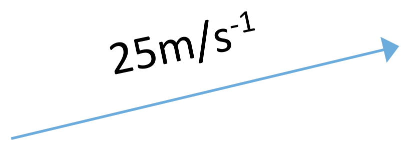
Eg, temperature, mass, distance

# Vectors

Vector - a physical quantity that has both magnitude (size) and direction

Eg, force, velocity, displacement, acceleration

Arrows are used to represent vector quantities. The length of the arrow  may be considered to be proportional to the vector quantity



# Newton’s Law of Gravitation

*All particles attract one another with a force proportional to the product of their masses, and inversely proportional to the square of the distance between them*

This can be expressed as:

$F = G \times ((m_1 \times m_2)/ d^2)$

Where: F = gravitational force, m = mass of objects, d = distance between, G = constant ($9.8 N/kg^{-1}$)

# Newton's First Law

*Every object will continue in a state of uniform motion in a straight line (or remain at rest) unless compelled to change it's state of motion by a net external force acting on it*

An objects reluctance to change it's state of motion is called inertia

Therefore, in order to change a state of motion, both the object's mass, and the force acting upon it, play a large role

# Force

Forces arise whenever objects interact with each other

Objects may or may not be in contact with one another

Forces are present at all times

Forces can be classified as follows:

| Non contact | Contact |
|---|---|
| Gravity | ‘Ground’ reaction forces |
| | Joint reaction forces |
| | Muscle forces |
| | Fluid forces |
| | Elastic forces |

As sports practitioners, we are primarily interested in gravity and ground reaction forces.

# Newton's Second Law

*The rate of change of momentum* of an object (or acceleration of an object of fixed mass) is directly proportional to the force causing the change, and the resulting change in momentum takes place in the direction in which the force was applied*

$F = m \times (m_f \times V_f) – (m_i \times V_i) / t$

Where: F = average force, $m_f$ = mass at end of time interval, $V_f$ = velocity at end of time interval, $m_i$ = mass at start of time interval, $V_i$= velocity at start of time interval, t = time interval, m = momentum ($kg/ms^{-1}$)

Or, if mass of the object is a constant (most sport), this equation can be simplified to:

$F = m \times a$

*Linear Momentum = Mass x Velocity

# Newton’s Third Law

*When one object exerts a force on a second object there is a force equal in magnitude but opposite in direction exerted by the second object on the first*

Often referred to as the ‘action/reaction law’

# Centre of mass/gravity (COM/COG)

A point representing the mean position of the matter in a body or system

A point at which a force acting upon an object, propels that object along the vector without rotation

An athlete's centre of gravity would be the centre point of the position in which the mass of the athlete was equally balanced within the contact area on the ground

# Weight

In physics, weight is calculated thus:

Weight = mass x G

Weight is measured in Newtons (N)

Eg, 10kg x 9.8N/kg = 98 Newtons

# Work done

Work done = force x distance

Work done is measured in Joules (J) or Newton metres (Nm) – see below

Force is measured in Newtons (N)

Distance is measured in metres (m)

# Impulse

Impulse is the application of a force over a period of time that causes a change in an objects movement. A force applied over a longer period of time will result in a bigger impulse than an equal force applied over a shorter period of time.

Impulse (J) = $F_{average}$ x $(t_2 – t_1)$

Where: $(t_2 – t_{1)}$ is the duration of the application of force