G626: The Physics of Sport – Exemplar Material 1
Leaflet on '*Measurement in Sport*'

The following pages contain a sample leaflet submitted as part of a Unit G626 portfolio. They should be read in conjunction with the assessment evidence grid in the unit specification.

Please note that for copyright reasons, images included by the candidate have been removed, but many of these can be viewed by following the references provided.

The four pages of the leaflet are designed to be printed in pairs, back to back. Check that the page numbers run sequentially.

ASSESSOR'S COMMENTARY ON MARK ALLOCATION

This leaflet achieves the requirements for the part of AO1 at Mark Band 3.

The work is thoroughly researched and sources are identified. Details of definitions of SI units go, if anything beyond that needed by an athletics coach and are ample for the size of leaflet. MB3 is therefore just achieved.

Please note: this candidate has written about five different quantities although only four are required. Marks are awarded for the best four.

Candidates should be discouraged from covering more than 4 quantities as this may reduce the depth to which each is covered within the space and time constraints. However, on this occasion, each of the five has been covered in sufficient depth to achieve MB3.

Sources:

Measurement in sport - the long and the short of it.
http://science. org.au/nova/033/033

Astro Products.
http://www.astroproducts.net/

Encarta
http://encarta.msn.com/encyclopedia_761562123_3/Track_and_Field.html
#endads

British Heart Foundation
http://www.bhf.org.uk

GCE Applied Science

Unit G626 - Physics of Sport

Example leaflet 1

'Measurement in Sport'

1. Measurement of Time in Running events

Units: The SI unit of time is the second (s).

Definition: The second is the duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium 133 atom.

Devices and Techniques:
A) *Hand-held stopwatches*

Limit of accuracy ± 0.2 s.

Limited by human judgement and reactions. Nobody can react in less than 0.110 of a second.

B) *Electronic quartz timing system*.

Limit of accuracy ± 0.01 s.

Introduced in international events 1964, a voltage makes a crystal of quartz (crystalline silicon dioxide) oscillate at an almost constant rate.

C) *The computerised timing systems.*

Limit of accuracy ± 0.001 s (10 times the accuracy required by the rules).

A transducer converts one form of energy into another. In this case, the transducer is connected to a starter's pistol and converts sound energy into electrical energy. The signal is sent to a computer, starting its clock. A video camera scanning a thin vertical line at finish, at up to 2000 times per second, produces a video image of the athletes as they pass the line. The image is superimposed with a time grid.

5. Heart rate monitoring.

Other examples of measurements made outside competition are those monitoring the human body.

One way in which coaches monitor the performance of their charges is to monitor the effect of exercise on their heart rate.

Units: The SI unit of heart rate is s^{-1},
but in practice beats per minute (bpm) is used.

Definition: These are both derived units based on the second, defined earlier.

Normal adult heart rate while resting = 60-90 beats per minute.

The fastest heart rate a person can reach is called the maximal heart rate. During exercise, heart rate should reach no more than 60–75% of maximal heart rate.

Maximal heart rate of a 20 year old when exercising ~ 200 bpm.
Maximal heart rate of a 60 year old when exercising ~ 160 bpm.

In general, maximal heart rate = 220-age in years.

Devices and Techniques:
Because of the wide spread in 'normal heart rates', high precision measurement is not required. Electronic personal heart rate monitors are now widely available and resemble wristwatches. Advertisements tend to stress their looks and features such as memories, 'calories burned' etc., rather than their accuracy or precision.

4. Mass of Shot

Some sports measurements do not directly measure the performance of athletes during competition. As sport becomes increasingly competitive, governing bodies tighten up the rules governing equipment. Some equipment specification has existed for many years, and one such example is the mass of the shot used in shot putting.

Units: The SI unit of mass is the kilogram (kg). This quantity is commonly referred to as weight in non-scientific language including sporting circles.

Definition: The kilogram is defined as equal to the mass of the international prototype of the kilogram.

The candidate included a magazine cover here illustrating the sporting theme. For the purposes of distributing this support pack, the image has been removed for copyright reasons.

Devices and Techniques:
In international competitions, minimum masses of shot are specified as:

men 7.26 kg (16 lb)
boys 5.44 kg (12 lb)
Women 4 kg (8 lb 13 oz)

It is measured using an electronic balance. The picture (below) shows a typical commercially available balance. The TE12000 version has a range up 12 kg in 1 g steps and is available for approximately £500.

The candidate included an image of a balance here as described in the text. This has been removed for copyright reasons.

2. Length of Shot Put Circle

Units: The SI unit of length is the metre (m).

Definition: The metre is the length of the path travelled by light in vacuum during a time interval of 1/299 792 458 of a second.

Devices and Techniques:
Lengths in the shot put are measured simply by a tape measure. The widths of the various lines marked out on the grass are 5 cm wide. However, since the distances involved are correspondingly large the % error is small.
For example + 1 cm in 10 m is a 0.1 % accuracy.

The sequence of pictures illustrates the techniques used. Note the twisted tape in one of the pictures!

The candidate included a series of 3 photographs of measuring shot put lengths with a tape. These have been removed for copyright reasons.

Picture 2

Picture 3

3 Velocity of Cricket balls.

Units: The SI unit of Velocity is the metre per second ($m\ s^{-1}$).

Definition: The metre per second is a derived unit defined in terms of the metre and the second, the definitions of which are given above.

Principle of the Doppler effect:
Waves reflected by moving objects undergo a change of frequency. If a reflector (such as a ball) is moving towards the source and detector, the waves are compressed together, so that the wavelength decreases and the frequency therefore increases. Radar guns, such as those used in police speed traps, transmit a radar signals and receive the reflected signal. They use the change in frequency to calculate the speed of vehicles. Similar devices can measure the speed of balls in, for example, cricket.

Devices and Techniques:
The illustration on the opposite page shows one commercial example of a sports radar gun. The Astro Products sports radar 3500 handheld radar gun is a low power Doppler radar transceiver. It operates at 10.525 GHz. This particular device is made in the USA so the 3 Digit LCD display gives readings in miles per hour. The speed range is from 5 to 150 miles per hour. In SI units this is 2.22 to 66.9 $m\ s^{-1}$.

Limit of accuracy = ± 1 MPH or approx ± 0.5 $m\ s^{-1}$.

According to the specification, as well as measuring the speed of balls at distances up to 15 m, it also will measure bat swing speed. A device with a greater range would be required to monitor the speed of cricket balls from the boundary.

from Astro Products