



Components

	NAME	DESCRIPTION	AUDIENCE
	<i>Profile of a runner</i> teachers guide	This guide shows how a 100 m race can be used to introduce calculations of distance, velocity and acceleration.	teachers
	<i>Profile of a runner</i> video	This video features a runner in a simulated 100 m race. It identifies acceleration, maintenance and slowing down phases of the race, and describes physical principles that underpin a runner's progress. Biomechanical research at The University of Western Australia shows analysis of a runner's performance.	students
	<i>Describing motion</i> worksheet	A two-part worksheet provides key questions to guide students in considering the nature of forces and their effects on objects.	students
	<i>Newton's laws of motion</i> fact sheet	Newton's three laws of motion are summarised, with examples.	students

Purpose

Students apply their understanding of unbalanced forces to **Explain** the motion of a runner. They analyse graphical data and perform calculations of velocity, acceleration, deceleration and forces acting on a runner.

Outcomes

Students describe and apply concepts of distance, displacement, speed, velocity and acceleration, for objects moving with constant velocity and uniformly accelerated rectilinear motion.

This includes applying relationships:

$$v_{av} = \frac{s}{t}$$

$$v_{av} = \frac{v + u}{2}$$

$$a = \frac{v - u}{t}$$

$$F = ma$$

Activity summary

ACTIVITY	POSSIBLE STRATEGY
Teacher introduces a scenario of a runner during a 100 m sprint and poses questions: <ul style="list-style-type: none"> How does a runner's performance change during a 100 m race? What measurements would we need to make to answer the first question? How can this information be used to improve a runner's performance? Students either call out answers or discuss in small groups.	teacher introduction
Teacher shows video, <i>Profile of a runner</i> , facilitates discussion and answers questions that arise.	'Think, pair, share' or small group discussion
Teacher distributes fact sheet, <i>Newton's laws of motion</i> .	whole class
Students complete worksheet, calculating displacement, velocity, acceleration and force in the context of a 100 m race.	individually or in small groups

Using the video, *Profile of a runner*

The video contains the following sections.

The opening sequence features a Brisbane athletics meeting in which 2008 Olympic silver medallist Sally Pearson (then known as Sally McLellan) wins the 100 m race.
An athlete at UWA simulates a 100 m race to illustrate how it can be broken down into three phases: drive (or acceleration); maintenance; and slowing down. The runner's actions are analysed to show how he achieves maximum acceleration at the start of the race; maintains maximum velocity for as long as possible during the major part of the race; but eventually fatigues and slows down.
The athlete's posture and movements are analysed during the three phases of the race to show how force, acceleration and Newton's laws are applied to maximise his performance.
Inside the biomechanics laboratory, the runner simulates the 100 m race on a treadmill. The video briefly describes how a treadmill and strain gauge are used to gather data to analyse the runner's performance in terms of velocity, acceleration, force, work and power.

Table 1: Content of video, *Profile of a runner*

Using the worksheet, *Describing motion*

The worksheet is provided in two sections, which may be used together as an in-class activity or separately as an in-class activity and assessment tool.

Part 1 of the worksheet includes items in which students analyse graphical data and perform calculations of velocity, acceleration and force using the equations of motion and force.

Part 2 of the worksheet contains data from Usain Bolt's 100 m race at the Beijing Olympic games. It is based on analysis of the race by Jimson Lee (Speed Endurance, 2008).

Most world-class 100 m male sprinters reach their top speed within 50–60 m. Female sprinters usually reach their top speed earlier, so more of their race depends on speed endurance.

Usain Bolt won the 2008 Olympic Games 100 m because of his speed endurance – that is, his ability to maintain the same top speed for more of the race.

The IAAF released Bolt's official splits (ie the times for each 10 m). These data and the calculated average velocity are shown in Table 2.

SPLIT (m)	TIME (s)	AVERAGE VELOCITY (m s ⁻¹)
reaction time	0.165	
0–10	1.70	5.88
10–20	1.00	10.00
20–30	0.90	11.11
30–40	0.87	11.49
40–50	0.85	11.76
50–60	0.84	11.90
60–70	0.82	12.20
70–80	0.83	12.05
80–90	0.85	11.76
90–100	0.86	11.63
Total	9.685	

Table 2: Data from Usain Bolt 100 m race, Beijing Olympics (2008)

Note: to convert m s⁻¹ to km h⁻¹, multiply by 3.6 (a factor of 3600/1000).

Until Usain Bolt raced, 0.83 s was the fastest split time recorded. A time of 0.83 s per 10 m translates to 12.05 m s⁻¹ or 43.3 km h⁻¹.

During the final 10–15 m of the race, Bolt began celebrating his impending victory. This caused his time to increase slightly. Extrapolating his last 10 m segment, without the chest thumping, it would be fair to say he could have run 0.84 or 0.85 s, making his 100 m World record 9.63 or 9.64 s.

References

Speed Endurance. (2008). *Usain Bolt 100 m 10 m splits and speed endurance*. Retrieved February 22, 2013 from <http://speedendurance.com/2008/08/22/usain-bolt-100m-10-meter-splits-and-speed-endurance/>

Image credits

fact sheet, *Newton's laws of motion*

- portrait of Sir Isaac Newton courtesy of the University of Texas Libraries, The University of Texas at Austin
- 'Fuji apples' by Scott Bauer, USDA ARS, PD-USGOV-Agriculture, commons.wikimedia.org/wiki/File:Fuji_apple.jpg

banner image: 'Varsity running track Toronto' by Kenzie. CC-BY-2.0, www.flickr.com/photos/dark-wretch/4776236450/

Technical requirements

The teachers guide and worksheet require Adobe Reader (version 5 or later), which is a free download from www.adobe.com. The worksheet is also available in Microsoft Word format. QuickTime version 7 or later is required to view the video. This is a free download from www.apple.com/quicktime.

A high-quality MP4 version of the video with subtitles is also available on CD-ROM or download from the SPICE website.

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Associated SPICE resources

Motion 2: Profile of a runner may be used in conjunction with related SPICE resources to address the broader topic of motion.

DESCRIPTION	LEARNING PURPOSE
<p><i>Motion (overview)</i></p> <p>This learning pathway shows how a number of SPICE resources can be used to teach concepts of motion.</p>	
<p><i>Motion 1: Unbalanced forces and motion</i></p> <p>Images from various sports stimulate discussion of effects of forces on motion of objects.</p>	Engage
<p>The sequence overview contains suggested Explore activities suitable for use at this point.</p>	Explore
<p><i>Motion 2: Profile of a runner</i></p> <p>A 100 m race is used as a context for analysing motion, velocity and acceleration.</p>	Explain 1
<p><i>Motion 3: Tennis ball motion</i></p> <p>Students use equations of motion to analyse slow-motion footage of a bouncing tennis ball.</p>	Explain 2
<p><i>Motion 4: Sporting injuries</i></p> <p>A biomechanist and surgeon provide perspectives on knee injuries in athletes. Data on injuries, for a range of sports, are analysed. Students make connections between prevalence of injuries and forces in the human body.</p>	Elaborate