

Topical Applications of Mathematics

Heptathlon

TEACHER INFORMATION

Key Stage 3 or 4

Target High ability Y8/9 and mainstream GCSE

MEP references GCSE Y10/11, Unit 2 Formulae

Teaching notes This is a very practical application of mathematics that is topical now and will be until at least 2012.

The Beijing Olympic Games will be in the news for the first six months of 2008 as our athletes train and practise in their attempts to reach the minimum qualifying points score that will enable them to complete.

The following 4 years will see the build-up to the London Olympics in 2012: there will be more, improving UK athletes coming into the public eye over this period, as well as our current two real hopes for medals, Kelly Sotherton

http://en.wikipedia.org/wiki/Kelly_Sotherton

and Jessica Ennis

http://en.wikipedia.org/wiki/Jessica_Ennis

Much of the background to this event can be found at

<http://en.wikipedia.org/wiki/Heptathlon>

a useful source of reference, particularly for students working on this topic on their own.

The full details of the heptathlon at the 2007 International Association of Athletics Federations (IAAF), World Championships in Athletics, held in Osaka, Japan, in August 2007 can be found at

http://en.wikipedia.org/wiki/2007_World_Championships_in_Athletics

The mathematics needed is an ability to cope with calculations and manipulations with formulae, including non-integer powers. Revision of working with powers might be needed for some classes.

The actual design of the points formulae is dealt with in the **Appendix** and could be the focus of a complete lesson. Alternatively, the formulae could be stated, with some background information given about their derivations.

Details of the Men's Decathlon can be found at

<http://en.wikipedia.org/wiki/Decathlon>

and

<http://geocities.com/mdetting/sports/>

Solutions and Notes for material in the Pupil Text**Activity 1**

A useful website for this activity is

<http://www.sportsofworld.com/olympics/sporting-events.html>

Activity 2

Weakest: Javelin *Strongest:* Long jump

Although she scored over 1000 in 4 events, her javelin result of 776 points is very low and this causes her average to be just over 1020.

Activity 3

Various answers could be given here. For example,

- no UK athlete in the top ten
- apart from the Klüft entry at no. 2, most of these events took place some time ago with 6 actually in the 1980s, when there is a suggestion that illegal drugs enhanced some performances, particularly for East German competitors.

Activity 4100 m hurdles

Name	Time	Points	RANK order
Klüft	13.15	1102	2
Blonska	13.25	1087	4
Sotherton	13.21	1093	3
Ennis	12.97	1129	1

Activity 5*(a)* Running events

Name	100 m h	200 m	800 m	Total (rank)
Klüft	1102	1041	927	3070 (3)
Blonska	1087	972	869	2928 (4)
Sotherton	1093	1039	942	3074 (2)
Ennis	1129	1064	944	3137 (1)

- (b) From the analysis above, the two UK athletes do very well in the running events and, from the results table, their high jump and long jump results are close to the other competitors'. Shot put and javelin appear to be their weakest events. We do need to see the actual points for these events to be able to make any real judgements.

Activity 6

Name	Points				Points for		Total Points	(Rank)
	H. j.	S.p.	L.j.	Jav.	Field events	Track events		
Klüft	1171	848	1122	821	3962	3070	7032	(1)
Blonska	1132	823	1132	817	3904	2928	6832	(2)
Sotherton	1054	803	1066	513	3436	3074	6510	(3)
Ennis	1093	656	953	630	3332	3137	6469	(4)

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Heptathlon

SAMPLE LESSON PLAN

Note: this lesson plan is designed for GCSE classes. It is an example of the use of functional mathematics: that is, mathematics used in a meaningful context.

Activity		Notes				
		T: Teacher P: Pupil				
1	<p>Introduction</p> <p>T: Who can tell us anything about the heptathlon? <i>Athletics competition for women: comprises 7 events</i></p> <p>T: Does anyone know what the 'hepta' part of the word 'heptathlon' tells us? <i>hepta – Greek for 7</i></p> <p>T: Do you know which events make up this 2-day competition?</p> <table border="1" style="margin-left: 40px;"> <tr> <td>DAY 1</td> <td>100 m hurdle High jump Shot put 200 m</td> </tr> <tr> <td>DAY 2</td> <td>Long jump Javelin 800 m</td> </tr> </table> <p>T: Can you suggest why the heptathlon takes 2 days to be completed? <i>(Too exhausting for one day; takes too long if there are many competitors)</i></p> <p>T: With so many different sports included, how is the winner chosen? <i>(A points system is used)</i></p> <p>T: How is the points system decided on? <i>(A formula is used)</i></p> <p>T: Look at your data sheet. This shows the world record performance of Jackie Joyner-Kersey in the 1988 Olympic Games in Seoul.</p> <p>T: The points system is based on a norm of about 1000 per event, with better performances scored over 1000. What are this competitor's weakest and strongest events? <i>(Weakest: javelin Strongest: long jump)</i></p> <p style="text-align: center;"><i>10 mins</i></p>	DAY 1	100 m hurdle High jump Shot put 200 m	DAY 2	Long jump Javelin 800 m	<p>Many Ps will have at least some knowledge of this competition. Try to get Ps to discuss what they know, intervening and encouraging where necessary.</p> <p>Discuss the possible events and why these specific ones are included. (They represent different athletics skills.)</p> <p>Again, encourage class discussion for the following questions.</p> <p>Maybe consider other ways of obtaining a winner (for example, with 8 competitors you could award 10, 8, 6, 5, 4, 3, 2, 1 points for 1st, 2nd, 3rd, ... place).</p> <p>Ps work in pairs with a copy of Data Sheet 1.</p> <p>Ps (volunteers or chosen by T) should be encouraged to describe how the formula works.</p>
DAY 1	100 m hurdle High jump Shot put 200 m					
DAY 2	Long jump Javelin 800 m					

<p><i>Activity</i></p> <p>2</p>	<p>Best performance</p> <p>T: Look at Data Sheet 2. Work in pairs: I'll give you 3 minutes to consider what is shown by this data.</p> <p>T (after 3 minutes): Who can tell us something about the data? <i>(Most of the records are from the 1980's; 3 out of 10 are from East Germany; no British athletes in the list)</i></p> <p>T: Although there are no UK athletes in the list, we have had a recent Olympic Gold Medal (Denise Lewis, Sydney Olympics, 2000) and we have two excellent chances of medals in this event in Beijing with our athletes Kelly Sotherton and Jessica Ennis</p> <p style="text-align: center;"><i>15 mins</i></p>	<p>Notes</p> <p>Let Ps have a few minutes to consider any implications that are shown by the data. T could provide a suggestion such as "Look at the dates", or "Look at the countries" but only if help really is needed.</p> <p>T leads discussion of various aspects of the data and the UK's hopes for 2008.</p>
<p>3</p>	<p>IAAF World Championships in Athletics</p> <p>T: The women's heptathlon event took place on 25 and 26 August 2007 in Osaka, Japan. Data Sheet 4 shows the top performers.</p> <p>T: We need to convert the times and distances to points so that we can calculate the scores. For TRACK events, we use the first formula shown on Data Sheet 3. You will need your calculator for this!</p> <p>T: Who would like to convert the first one, the 100 m hurdles, completed by Caroline Klüft in 13.15 seconds?</p> <p>P (at board):</p> $P = 9.23076 \cdot 26.7 - 13.15^{1.835}$ $\approx 1102.42 \quad (\text{using calculator})$ <p>Points = 1102</p> <p>T: Who agrees/disagrees with this calculation?</p> <p>T: Now use the formula to calculate the points scored by the other 3 competitors in the 100 m hurdles. Write them on your copy of Data Sheet 4. You have 5 minutes to do this.</p> <p>T (after 5 minutes): Let's check the answers. Who would like to give us their answer for Lydmila Blonska's points? Write the calculation on the board, please.</p>	<p>T hands a copy of Data Sheet 4 to each pair of Ps.</p> <p>T should rewrite the formula for each event on the board, i.e.</p> <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 10px auto;"> <p>For 100 m hurdles,</p> $P = 9.23076 \cdot 26.7 - M^{1.835}$ </div> <p>Other Ps agree/disagree. Any other answers are discussed: T ensures that all Ps understand where and why they have made errors. T ensures that all Ps know what to do and then should monitor, encourage and help where necessary, 3 other Ps are chosen to give their solutions for the other competitors. If all Ps understand, answers can be given verbally from the Data Sheets. Otherwise the full calculations can be written on the board - with pace!</p>

<i>Activity</i>		<i>Notes</i>								
	<p>P (at board):</p> $P = 9.23076 \cdot 26.7 - 13.25^{1.835}$ $P \approx 1087.53 \quad (\text{using calculator})$ <p>Points = 1087</p> <p>Kelly Sotherton</p> $P = 9.23076 \cdot 26.7 - 13.21^{1.835}$ $P \approx 1093.48 = 1102 \quad (\text{using calculator})$ <p>Points = 1093</p> <p>Jessica Ennis</p> $P = 9.23076 \cdot 26.7 - 12.97^{1.835}$ $P \approx 1129.44 \quad (\text{using calculator})$ <p>Points = 1129</p> <p>T: Let's look at the points for the other 2 track events: the 300 m and 800 m.</p> <p>T: Work out the points scored, write them on your copy of Data Sheet 4 and in a few minutes we'll give our answers.</p> <p>T: Now we'll turn to the FIELD events. For these, the second formula on Data Sheet 3 is used.</p> <p>Why are there two different formulae? <i>(Because higher values are now best)</i></p> <p>T: We need to complete Data Sheet 4 by calculating and entering all the points scored.</p> <p>T: Read out your results as I ask you. <i>(Ps give answers and T checks them)</i></p> <p>T: How do we find out who is the overall winner of the heptathlon? <i>(Calculate the total points scored by each competitor)</i></p> <p>T: Now you can complete this task.</p> <p>T: What are the final points scored?</p> <table data-bbox="494 1556 686 1713"> <tr><td>Klüft:</td><td>7032</td></tr> <tr><td>Blonska</td><td>6832</td></tr> <tr><td>Sotherton</td><td>6510</td></tr> <tr><td>Ennis</td><td>6469</td></tr> </table> <p>T: These were, in fact, in order and Kelly Sotherton did win a Bronze medal.</p> <p>T: Which events should Sotherton and Ennis concentrate on in order to do even better in Beijing in 2008?</p> <p style="text-align: center;"><i>35 mins</i></p>	Klüft:	7032	Blonska	6832	Sotherton	6510	Ennis	6469	<p>Other Ps agree/disagree and help one another to deduce the correct points scores.</p> <p>T should sort out any problems at this stage so that all Ps are able to complete this activity.</p> <p>The task could be shared around the class in order to speed the process.</p> <p>T asks Ps for answers. Any problems should be discussed: effective use of calculators might be an issue to focus on.</p> <p>Again, this can be shared around the pairs so that the task is completed quickly.</p> <p>T chooses Ps to give answers.</p> <p>T should make sure each pair of Ps has a complete (correct) set of points data.</p> <p>All the pairs should do this, with T checking the final results.</p> <p>T sorts out any errors in calculation with the help of the whole class.</p> <p>Discussion here: conclusion is that <i>javelin</i> and <i>shot put</i> are the weakest events for these two athletes.</p>
Klüft:	7032									
Blonska	6832									
Sotherton	6510									
Ennis	6469									

<i>Activity</i>		<i>Notes</i>																																													
4	<p>Points Scoring Systems</p> <p>T: We've used the official points system and seen that it is quite complicated. Can you design a simpler system?</p> <p>T (after 5 minutes): What suggestions can you make for a simpler system?</p> <p>P: Perhaps 4 points for the winner, 3 for second place, etc.</p> <p>T: Let's try this system on the 4 competitors we have data for.</p> <p style="padding-left: 40px;">Work in pairs for 2 minutes to calculate the rank order using this system.</p> <p>T: Who has the results? Please write them on the board for us.</p> <p>P (on board):</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th></th> <th>100 mh</th> <th>h.j.</th> <th>s.p</th> <th>200 m</th> <th>1.j.</th> <th>jav</th> <th>800 m</th> <th>Tot. Rank</th> </tr> </thead> <tbody> <tr> <td>Klüft:</td> <td>3</td> <td>4</td> <td>4</td> <td>3</td> <td>3</td> <td>4</td> <td>2</td> <td>23 (1)</td> </tr> <tr> <td>Blonska:</td> <td>1</td> <td>3</td> <td>3</td> <td>1</td> <td>4</td> <td>3</td> <td>1</td> <td>16 (3)</td> </tr> <tr> <td>Sotherton</td> <td>2</td> <td>1</td> <td>2</td> <td>2</td> <td>2</td> <td>1</td> <td>3</td> <td>13 (4)</td> </tr> <tr> <td>Ennis:</td> <td>4</td> <td>2</td> <td>1</td> <td>4</td> <td>1</td> <td>2</td> <td>4</td> <td>20 (2)</td> </tr> </tbody> </table> <p>T: What a difference! Ennis now has the SILVER medal. But is this fair? <i>(Not really, as actual performances are hidden by using this approach)</i></p> <p style="text-align: center;"><i>45 mins</i></p>		100 mh	h.j.	s.p	200 m	1.j.	jav	800 m	Tot. Rank	Klüft:	3	4	4	3	3	4	2	23 (1)	Blonska:	1	3	3	1	4	3	1	16 (3)	Sotherton	2	1	2	2	2	1	3	13 (4)	Ennis:	4	2	1	4	1	2	4	20 (2)	<p>T introduces discussion on the points system, encouraging Ps to contribute and praising suggestions of other possible methods.</p> <p>Discussion on the merits/ disadvantages of this simpler system.</p>
	100 mh	h.j.	s.p	200 m	1.j.	jav	800 m	Tot. Rank																																							
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5	<p>Homework</p> <ol style="list-style-type: none"> Set the Worked Example from the Appendix on the derivation of the formula. Investigate the systems used for the MEN'S DECATHLON. 																																														