OCR
Oxford Cambridge and RSA

Thursday 15 May 2025 – Afternoon

Level 3 Certificate Core Maths B (MEI)

H869/01 Introduction to Quantitative Reasoning

Insert

Time allowed: 2 hours

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INSTRUCTIONS

- Do **not** send this Insert for marking. Keep it in the centre or recycle it.

INFORMATION

- This Insert contains the pre-release material that you have already seen.
- This document has **8** pages.

A Online advertising

Billions of pounds are spent annually on online advertising. A billion is a thousand million.

The words 'advertisement' or 'advert' are usually shortened to just 'ad'. Other terms often used in online advertising include:

- 'impression' – which is a single instance of an ad appearing on a screen
- 'view' – which is each time someone actually looks at the ad.

Advertising companies usually charge for impressions, rather than views.

Advertising companies report to (and charge) their customers on the following metrics:

Cost Per Mille (CPM)
The price an advertiser pays for a thousand impressions of their ad. (Note that advertising companies count impressions, rather than views, so this does not necessarily indicate the number of times the ad was seen.)

Click Through Rate
The percentage of impressions resulting in a person clicking on the ad.

Conversion Rate
The percentage of people who take the intended action out of those who click on the ad. The intended action could be making a purchase, subscribing to a newsletter, completing a survey etc.

Example
A college allocates £480 for advertising its upcoming courses.
It is aiming to gather information, using a survey, about potential new students.

The advertising company has a **CPM** of £3.20. So, £3.20 buys 1000 impressions of the ad. The college can buy 150 000 impressions with their budget of £480.

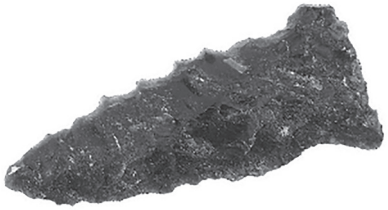
Out of these 150 000 impressions, 180 people clicked on the ad.
This is a **Click Through Rate** of 0.12%.

27 out of the 180 people who clicked on the ad completed the survey (the ad's primary objective).
This is a **Conversion Rate** of 15%.

B Obsidian Rind

Obsidian is a type of volcanic glass found worldwide. It's usually black and can break easily. When it breaks, it forms very sharp edges. Ancient cultures used these sharp edges to make weapons and tools like arrowheads and hand axes (see **Fig. B.1**).

Fig. B.1



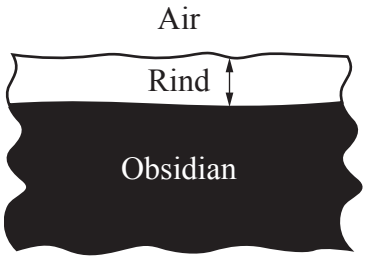
Obsidian arrowhead

Obsidian hand axe

When an obsidian object is chipped during making, the fresh surface produced begins to absorb water from the air. This forms a layer on the obsidian surface, called a rind.

The rind on the surface of a piece of obsidian is shown in cross-section in **Fig. B.2**.

Fig. B.2



Over time, the rind becomes thicker. Measuring the rind thickness gives a method to estimate the time since the object's surface was first exposed to the air (when it was made).

Rinds on obsidian are very thin and are usually measured with a microscope. The thickness is measured in microns and can range from 1 micron (for very young objects) to over 30 microns (for objects that are thousands of years old). 1 micron is 10^{-6} m.

The rate at which the rind forms is affected by several factors, including the temperature and the humidity of the environment. Archaeologists use objects of known age to calibrate the rind thickness rate. Once the rind thickness rate is known, this can be used to date other obsidian objects from the same source and similar environmental conditions.

This method is most effective for dating objects that are between 500 and 200 000 years old. If the object has been exposed to variations in temperature over time, this can affect the accuracy of the dating. However, it does have the advantage of being simple and very cheap compared with some other methods.

C Just Noticeable Difference (JND)

A stimulus is something people can sense, like the brightness of light, the volume of music, the mass of an object, or the sourness of a drink.

The term 'JND' or 'Just Noticeable Difference,' is the smallest change in a stimulus that people can sense. Nearly two centuries ago, psychologists wondered how the JND (Just Noticeable Difference) in mass varied with different initial masses. They considered questions such as:

'The JND for a 1000 g mass is 49 g, would it be the same for a 2000 g mass?'
'If not, how does the JND change with initial mass?'

Fig. C.1 shows some of their findings.

Fig. C.1

Initial mass (g)	**JND for this mass (g) (decrease or increase)**	**$\frac{\text{JND}}{\text{Initial mass}}$**
500	23	0.046
1000	49	0.049
1500	77	0.051
2000	89	0.045
2500	121	0.048
3000	137	0.046

Psychologists noticed that, although the JNDs are different for each particular initial mass, the value of $\frac{\text{JND}}{\text{Initial mass}}$ does not significantly change.

After many different experiments involving other stimuli, such as volume of sound, sourness of a liquid and brightness of light this general model was proposed:

$W = \frac{J}{x}$

where
W is called the Weber fraction,
J is the JND for the stimulus x,
x is the initial value of the stimulus.

Note that J and x must be in the same units, so for mass: kg, g, pounds, tonnes etc.

The value of W, the Weber fraction, depends on the type of stimulus. For example, for sound loudness it is 0.05 and for light brightness it is 0.02.

Many psychologists now take the JND to be the 'maximum change that is **not** noticeable'.

Using this definition of JND, J, means that the Weber fraction $W\left(=\frac{J}{x}\right)$ gives the maximum **fractional** change in the stimulus x that is **not** noticeable.

JNDs can be used to alter a stimulus in stages without users noticing, for example:
to increase the shelf life of a fruit drink, a company wants to increase the concentration of one of its flavourings used in one of their drinks.

- The present flavouring concentration is 15 g/litre (15 g of flavouring in 1 litre of drink).
- Experiments show that the Weber fraction for this stimulus (flavouring concentration) is 0.03.
- After about two months customers 'forget' the previous flavouring concentration.
  So, if a JND change is made every two months, customers will not notice the difference.

This means that if the company increase the stimulus (flavouring concentration) by 1.03 times its previous value (a 3% increase) every 2 months, their customers will not notice the change.

Fig. C.2 shows the changes in stimulus over a course of 6 months.

Fig. C.2

After	**Stimulus (flavouring concentration g/litre)**		**Stimulus two months later (flavouring concentration g/litre)**
Start	15	→	$15\times(1.03)$
2 months	$15\times(1.03)$	→	$\left[15\times(1.03)\right]\times(1.03)$
4 months	$15\times(1.03)^2$	→	$\left[15\times(1.03)^2\right]\times(1.03)$
6 months	$15\times(1.03)^3$	→	$\left[15\times(1.03)^3\right]\times(1.03)$

After 6 months the stimulus (flavouring concentration) will be $15\times(1.03)^3$, which is 16.4 g/litre (1 d.p.). This corresponds to an increase of about 9% that was undetected by consumers.

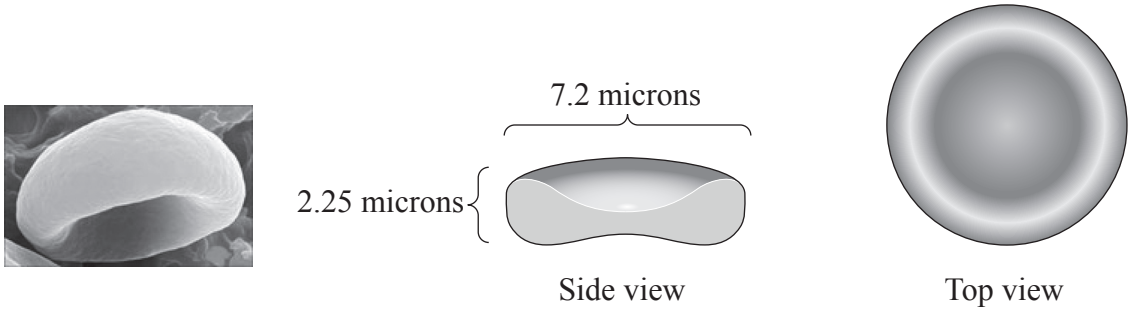
D Blood

Blood consists of four main components: red cells that deliver oxygen, white cells that combat infections, platelets that help in clotting to prevent bleeding, and plasma, the liquid that carries these components throughout the body.

Blood gets its colour from its red cells. These are in the shape of a disc that is curved inwards on both sides.

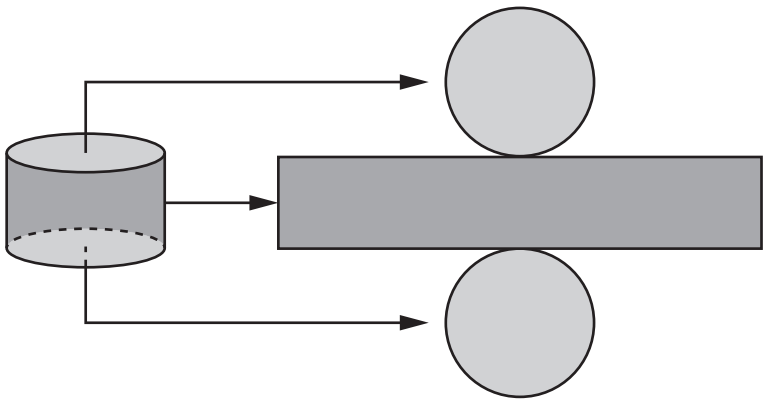
A typical red blood cell is shown in **Fig. D.1**. It is a complicated shape.
The measurements are in microns. (A micron is 10^{-6} m.)

Fig. D.1



They may be modelled as thin cylinders, as shown in **Fig. D.2** with surface area the sum of the area of the cylinder's flat circular top and bottom and its curved side, a rectangle.

Fig. D.2



Everyone has a unique blood type or group, one of four main groups: A, B, AB, and O. It is crucial to match the right blood group when giving/donating or receiving blood to avoid harmful reactions. A brief summary is given in **Fig. D.3**.

Fig. D.3

Blood type	Can donate to blood type	Can receive from blood type
A	A and AB	A and O
B	B and AB	B and O
AB	AB	A, B, AB and O
O	A, B, AB, and O	O

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