Cambridge Assessment
Admissions Testing

# THE INTERNATIONAL MEDICAL ADMISSIONS TEST (IMAT) PREPARATION GUIDE

In partnership with
Ministero dell'Istruzione, dell'Università e della Ricerca (MIUR),
the Italian Ministry of Higher Education and Research

*2018*

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# Introduction

## The International Medical Admission Test (IMAT)

The International Medical Admissions Test (IMAT) is a subject-specific admissions test in English, designed by Cambridge Assessment Admissions Testing for applicants to Medicine and Surgery courses at Italian International Medical Schools.

These courses are taught in English, with places open to both home and international students. Cambridge Assessment Admissions Testing was appointed by the Italian Ministry of Higher Education and Research (MIUR) to specifically develop IMAT in 2011, a test designed uniquely for admission to English-taught medical degrees at Italian universities.

Cambridge Assessment Admissions Testing (http://www.admissionstestingservice.org) is a global leader in the development of university admissions tests with more than 10 years' experience in the field, working with leading universities in the UK and worldwide to develop and administer assessments as part of the admissions process. Their evidence-based assessments are supported by rigorous and on-going research to ensure that they provide useful and fit-for-purpose information to support university admissions decisions. They are committed to ensuring that all our assessments are fair, have sound ethical underpinning and operate according to the highest technical standards.

Cambridge Assessment Admissions Testing is part of Cambridge Assessment, a not-for-profit department of the University of Cambridge. Cambridge Assessment is the University of Cambridge's international exams group, designing and delivering assessments to over 8 million learners in over 170 countries.

In conjunction with Admissions Testing, the Italian Ministry of Higher Education and Research has a yearly review of IMAT's design and format. The details of the review are released near the test date by Ministerial Decree and are available on MIUR's website: http://accessoprogrammato.miur.it

## Purpose of the IMAT guide

This guide sets out to provide candidates with the necessary information to prepare for IMAT, the entrance examination for undergraduate courses to Medicine and Surgery courses at Italian International Medical Schools. Many examples and detailed explanations about each question type in the admission test are available here, enabling candidates to become familiar with the style of questions and the format of the test.

Using this guide, candidates will be able to feel more confident that they have developed the skills and knowledge needed to achieve the best possible result.

This guide is approved by MIUR and it provides the official specification of both the format and contents of IMAT.

## General information and test specification

Previous IMAT papers included a total of 60 multiple-choice questions. All questions had five options, of which only one is correct.

Candidates have to answer various kinds of questions related to general knowledge, logical reasoning and several scientific disciplines. In order to be able to correctly identify the right answer in each of the sections, students shall:

1. have a solid general knowledge in the literary, philosophical, historical, social, political and institutional spheres;

2. develop logical reasoning skills related to all the proposed types; to this end, it is essential to become familiar with the materials in this guide and with the practice material for test-takers on Cambridge Assessment Admissions Testing's website (www.admissionstestingservice.org);

3. have a good knowledge of the scientific disciplines required in accordance with the Ministerial Program for secondary schools for Biology, Chemistry, Mathematics and Physics, as detailed in this guide.

IMAT does not require a great amount of extra study as it relies on skills and knowledge that candidates should already have. Candidates can familiarise themselves with the test format by downloading the test specification and past papers from the Cambridge Assessment Admissions Testing website:

http://www.admissionstestingservice.org/for-test-takers/imat/preparing-for-imat/

The format of the test is 60 multiple-choice questions with five options each. The five options might initially all seem plausible, but the students will have to choose not only based on their knowledge on the subject, but above all, using their own logical reasoning skills applied to various subjects.

The questions are divided according to the following sections:

**Section 1**
20 questions - Logical Reasoning
2 questions - General Knowledge

**Section 2**

18 questions - Biology

**Section 3**
12 questions - Chemistry

**Section 4**
8 questions - Physics and Mathematics

Please note that the order in which the questions are presented in the test is not the same as the order in this guide: questions will be randomised for each exam paper, so each candidate's exam will have a different order of questions and answers.

Furthermore, although questions have varying degrees of difficulty, they will not be presented in any particular ascending or descending order of difficulty.

A candidate's total score is calculated using the following formula:

1.5 points for each correct answer
-0.4 points for each wrong answer
0 points for each question not answered.

An overall total score (maximum 90 points) will be reported, together with a score on each section.

Candidates have 100 minutes to complete the test.

## Practical advice on how to prepare for IMAT

In order to achieve a good result, candidates must be able to answer correctly as many questions as possible in the time available. Therefore, time management is crucial: candidates are advised to practice with past papers under timed conditions so as to use the time effectively and try to avoid dwelling excessively on certain questions.

IMAT is designed to give candidates enough time to answer all of the questions if they work efficiently. If it is difficult to make progress with a question, a candidate can move on to a different question and then come back to the question later on. Candidates are not restricted to doing the questions in the order that they appear on the question paper. Sometimes, the best strategy can be to focus on particular types of question depending on individual strengths and preferences. A useful tip on how to manage the time available effectively is to practice spending no more than a minute and a half for each question. This will help optimize the time, so that candidates quickly answer the questions they find easier, and have more time for more challenging questions.

It is essential that candidates practice answering multiple choice questions in all the sections, in order to speed up their response skills to the questions. The only way to deal confidently with IMAT is to practice, as much as possible, answering questions similar to those that appear in this guide, so as to become familiar with the question format and the time available to answer. This is particularly applicable to those questions in the Logical Reasoning section where the importance of carefully reading each question before answering and to take into consideration all five options presented cannot be overestimated. For further examples of Logical Reasoning questions, see the preparation materials for the Thinking Skills Assessment (TSA) and Bio-Medical Admissions Test (BMAT) on the Cambridge Assessment Admissions Testing website.

## Section 1: General Knowledge and Logical Reasoning

Section 1 will assess general knowledge and the thinking skills (i.e. logical reasoning) that students must possess in order to succeed in a course of study at the highest level. Such skills are basic to any academic studies, which often require students to solve novel problems, or consider arguments put forward to justify a conclusion, or to promote or defend a particular point of view.

### General Knowledge

General Knowledge questions may address a range of cultural topics, including aspects of literary, historical, philosophical, social and political culture.

These questions are not based on any specific part of school curricula; rather their aim is to test the candidates' interest and knowledge in a wide variety of fields. Candidates with a keen extra-curricular interest in current events and that regularly keep up to date with national and international news will be better prepared to answer this type of questions.

With general knowledge questions candidates may often know the correct answer, however they may sometimes be unsure and may be tempted to give up and move on to other questions.

There are actually some useful strategies that can be adopted to maximise your chances to correctly identify the right answer, as illustrated by the following examples.

**EXAMPLE 1:**

| |
|---|
| 'Dubliners' is a collection of short stories written by which author?<br><br>**A** J. Joyce<br>**B** F. O'Brien<br>**C** I. Svevo<br>**D** F. Kafka<br>**E** J-P. Sartre |

The correct answer is **A**. This is a typical literary-based general knowledge question.

In the event that the candidate was not already familiar with the literary work in question, it is still possible to try to respond through a process of logical elimination. It is common knowledge that Dublin is in Ireland and therefore it can be safely assumed that the author is Irish. Therefore, the authors with surnames indicating other nationalities can be automatically eliminated, namely answers C, D and E. Now the candidate has narrowed the choice between A and B and has much better chances of answering correctly. Answer B is a "distractor" because it is a typical Irish surname, but one that does not correspond to the author of the work in question. This example illustrates how the student, in case of not knowing immediately the correct answer, can still benefit from a process of elimination using their logical reasoning skills. This approach can lead to correctly responding to a greater number of questions.

**EXAMPLE 2:**

| Which country was governed by the Taliban's theocratic regime from 1996 to 2001? |
|---|
| **A** Afghanistan<br>**B** Iran<br>**C** Iraq<br>**D** Saudi Arabia<br>**E** Syria |

The correct answer is **A**. This is a typical current affairs/recent history based general knowledge question.

This type of question aims to ascertain whether or not students follow recent events and are well-informed on major national and international affairs in the contemporary world. Those candidates who do not actively follow international news and are not keen readers of good quality newspapers and magazines will clearly be at a disadvantage.

**EXAMPLE 3:**

| Which of the following city-monument pair is wrong? |
|---|
| **A** Stockholm – Pont du Gard<br>**B** Rome – Theatre of Marcellus<br>**C** Athens – Erechtheion<br>**D** Istanbul – Hagia Sophia<br>**E** Split – Diocletian's Palace |

The correct answer is **A**. This is an interdisciplinary general knowledge question based on geographical as well as historical knowledge.

This example can also be solved by using logical reasoning skills – and linguistic skills and intuition, in this case – if the candidate does not know the correct answer immediately.

A possible logical method to arrive at the solution is to first identify the correct matches by recognising the linguistic characteristics of the monuments' names, even if the candidate does not know those specific monuments in particular. Therefore, answers B, C and D can be safely eliminated at the start. Answer E can be misleading and very attractive because the candidate might not know where Split is (i.e. Croatia) or because he/she might not know that this geographical area was heavily settled by Romans, hence the name "Diocletian". However, the correct resolution of the question hinges on the recognition that "Pont du Gard" is a typical French name and, therefore, it is not an extremely likely name for a monument in Stockholm, capital of Sweden.

The application of logic skills and linguistic abilities is often successful in solving interdisciplinary general knowledge questions.

**EXAMPLE 4:**

The World Heritage Convention, adopted by UNESCO in 1972, aims to identify and maintain a list of sites that may be considered:

**A** of exceptional cultural or natural importance
**B** of outstanding economic value
**C** to be characterized by a lasting peace
**D** to be conventionally suitable for human settlement
**E** to have exploitable energy resources

The correct answer is **A**. This is an example of a question based on culture and politics. In this case, the question is about the nature of a world organisation.

Even if the candidate does not have direct knowledge of this topic, the candidate should be able to immediately disassociate the term “heritage” with any answer relating to economy and finance, thus eliminating immediately answers B and E. By the same logic of elimination, C can be de discarded because peace does not relate to “heritage” in any way, leaving only two plausible options and increasing the chances of answering correctly.

Overall, general knowledge questions can cover topics ranging from authors and books to famous personalities, current affairs, history or inventions, world geography and much more. The aim is to test the students’ knowledge of the wider world and their ability to apply logical reasoning in different contexts. The best way to prepare for such questions is to read widely, across a range of different subjects and maintain an awareness of current affairs.

## Logical Reasoning

The aim of the questions in this section is to evaluate candidates' reasoning skills and analytic skills, especially the ability to follow the logical steps in different contexts, to recognise fallacies in the argument, to solve problems and to discern relevant from irrelevant information.

More specifically, there are two types of logical reasoning questions:

- Problem Solving: questions that involve reasoning using numerical and spatial skills.
- Critical thinking: questions that involve reasoning using everyday written language. Questions focus on the skills involved in understanding and evaluating arguments.

In order to successfully answer these questions, candidates must employ a logical approach. No previous knowledge of any particular subject is necessary. Candidates are strongly encouraged to familiarize themselves with the different types of questions by reading through this guide.

## Problem Solving

Problem Solving involves reasoning using numerical and spatial skills. The actual numerical and mathematical reasoning required for these questions is quite simple (certainly not at the same level as required for the mathematics questions in Section 4).

There are three kinds of problem solving questions:

1. Relevant Selection
2. Finding Procedures
3. Identifying Similarity

Although most questions fall into one category, some questions can fit into more than one of the categories. The examples following below show the different types of problem solving questions present in IMAT.

*Selecting relevant information*
Often a real-world problem will be overloaded with information, much of which is unimportant. The first step in solving the problem is to decide which bits of the information available are important. It may be that the question has presented you with information which is not important, perhaps redundant and possibly distracting. This kind of question demands relevant selection, in which the task is to select only that information which is necessary and helpful in finding a solution and then applying it.

*Recognising analogous cases*
In each of these questions you will be presented with information and asked to identify the same information presented in a different way, or the question will present a situation in which different information has a similar structure. Many of these questions can involve spatial reasoning ability.

*Applying appropriate procedures*
Sometimes you will find that even when you have selected all of the relevant information, no obvious solution presents itself. You then have to find a method or procedure which you can use to generate a solution from the information in the question. Typically you will have three or four numbers which have to be operated on in some way, or you will need to perform an operation a number of times.

## 1. Relevant Selection

Very often a real world problem will be overloaded with information, much of which is unimportant. This kind of question demands Relevant Selection, in which the task is to select only that information which is necessary and helpful in finding a solution.

The table below shows the price of various ladders. I need a ladder at least 8 m long to reach the gutters of my house. I want to store it in my garage which is only 4.2 m long.

| Length closed (m) | Length Extended (m) | Lightweight (Home use) | Heavyweight (Trade use) |
|---|---|---|---|
| Triple section ladders: | | | |
| 2.6 | 6.0 | €82 | €100 |
| 3.0 | 7.5 | €104 | €120 |
| 3.5 | 9.0 | €133 | €150 |
| 4.0 | 10.0 | -- | €169 |
| Double section ladders: | | | |
| 3.0 | 5.3 | €52 | €64 |
| 3.5 | 6.2 | €67 | €82 |
| 4.0 | 7.2 | €78 | €95 |
| 4.5 | 8.3 | €98 | €115 |
| 5.0 | 9.0 | -- | €140 |
| 5.5 | 10.0 | -- | €155 |

What is the lowest price I must pay to satisfy these conditions?

**A** €78
**B** €98
**C** €133
**D** €150
**E** €169

The answer is **C**. We need to find a ladder which extends to 8 metres but has a closed length of no more than 4.2 metres. There are no double section ladders which fit the requirements. Two triple section ladders are possible, one extending to 9 m and the other to 10 m. With heavyweight and lightweight options taken into account there are three possibilities. We require the cheapest and this costs €133.00. A lightweight ladder with a closed length of 3.5 m and an extended length of 9 m.

A €78 - lightweight - too short when extended
B €98 - lightweight - too long when closed
D €150 - heavyweight - more expensive than C
E €169 - heavyweight - more expensive than C

## 2. Finding Procedures

Sometimes you will find that even if you have selected all of the relevant information, no solution presents itself. You then have to find a method or procedure which you can use to generate a solution. Typically you will have three or four numbers which have to be operated on. This aspect of Problem Solving is called Finding Procedures.

Three thermometers are each accurate to within 2 degrees above or below the temperature they actually read. One reads 7°, one reads 9° and one reads 10°.

What is the minimum range in which the true temperature lies?

**A** 5° – 12°
**B** 7° – 9°
**C** 8° – 10°
**D** 8° – 9°
**E** 7° – 10°

The answer is **D**. The method here is to search for the acceptable highest and lowest temperatures for the conditions to be met, realising that the middle value is irrelevant. As one reads 7°, the temperature cannot be above 9° and, as another reads 10°, the temperature cannot be below 8°. This is given by D.

A This is obtained by subtracting 2 from the lowest and adding 2 to the highest.
B Takes the lowest reading and goes to 2 above it.
C Takes the highest reading and goes to 2 below it.
E Takes the range to be from the lowest reading to the highest reading.

## 3. Identifying Similarity

In this type of question you will be presented with information and asked to identify the same information presented in a different way, or a situation in which different information has a similar structure.

I wish to tile an area of wall 120 cm wide by 100 cm high. Tiles are 20 cm square. I will, therefore, need 6 x 5 = 30 tiles.

Which of the following uses the same method of calculation as that above?

**A** A staircase is 3 m high. Each step rises 0.25 m. Therefore, there are 12 steps.
**B** A room is 4.2 m by 2.0 m. Carpet costs €10.00 per square metre. Therefore, it will cost €84.00 to carpet the room.
**C** A box containing sugar cubes is 10 cm x 10 cm x 5 cm. A sugar cube is 1 cm on each side. Therefore, the box contains 500 cubes.
**D** Using square tables 1.5 m on each side, I need to make up a conference table that is 6 m x 3 m. Therefore I will need 8 tables.
**E** I work 40 hours a week and earn €5.00 an hour. Therefore, in 4 weeks I will earn €800.00.

The answer is **D**. The procedure of multiplying 6 x 5 is based on 6 tiles fitting along one edge and 5 tiles along another. In option D, 4 of the small tables will fit along the 6 m side and 2 along the 3 m side. The computation will therefore be 4 x 2.

Option A divides 3 by 0.25.
Option B multiplies 4.2 by 2.0 by 10.
Option C multiplies 10 by 10 by 5.
Option E multiplies 5 by 40.

Although in D there is a multiplication, this is the only case in which the numbers to be multiplied must first be obtained as they are in the tiling example.

## The mathematical knowledge and skills needed

### Number concepts

- simple fractions
- place value (for example, knowing that the "5" in "7654" indicates "50")
- ideas about percentages (for example, the idea that 1% could be thought of as "1 in every 100", and that if 20% of a group of adults are men, 80% must be women).

### Numerical operations

- the four rules of number (addition, subtraction, multiplication, division)
- percentage operations (for example, if something was sold at £10, and is now advertised at "20% off", how much would the customer pay?)
- calculations in everyday contexts (complex calculations with fractions and decimals are not required).

### Quantities

- time and the calendar
- money
- measures as shown below:

| Length | Weight | Area | Volume (capacity) |
|---|---|---|---|
| Kilometre (km)<br>Metre (m)<br>Centimetre (cm)<br>Millimetre (mm) | Kilogram (kg)<br>Gram (g) | Centimetre square ($cm^2$)<br>Metre square ($m^2$) | Cubic centimetre ($cm^3$)<br>Litre (l)<br>Gallon |

Knowledge of the following relationships is also required:
1 km = 1000 m  1 m = 100 cm  1 cm = 10 mm  1 kg = 1000 g

Also required is knowledge of the terms for measurements which are used informally in daily life (e.g. feet, miles), but numerical relationships for these measures (e.g. 12 inches = 1 foot) are not required.

### Space and spatial reasoning

- area (including the calculation of the area of a rectangle)
- perimeter (including calculation)
- volume (including the calculation of the volume of a box)
- reflections (in mirrors) and rotations of simple shapes
- two-dimensional (2D) representations of three-dimensional (3D) shapes (for example, being able to interpret a "bird's eye view" of a house).

### Generalisation

Recognition that some operations are generalizable, for example, that converting 24 to 3 and 40 to 5 both involve division by 8 (formal algebra is not required).

### Tables

- extracting information from tables.

## Critical Thinking

Critical Thinking in the context of the IMAT can best be made clear by the following definition: in an argument, reasons are put forward as grounds for a conclusion. The argument is a good argument provided its conclusion follows from the reasons. That is to say, if you accept the reasons, you must accept the conclusion.

For the purposes of the Critical Thinking element, the reasons given should be accepted as being true so that you can focus on the structure of the reasoning. When you are reading through the paragraph, it can be useful to identify different elements so that you can see the reasoning and particularly see the reasons that lead you to a conclusion. Identifying the reasons and the main conclusion is an important part of understanding the structure of an argument.

Here is an example of a simple argument:
Jill promised she would attend the meeting or send a substitute. We know she can't attend the meeting. So we are expecting a substitute.

The structure of this argument is as follows:

Reasons: Jill promised she would attend the meeting or send a substitute. We know she can't attend the meeting.

Conclusion: So we are expecting a substitute.

In this case, the conclusion appears at the end of the argument, and is introduced by the word "so". Sometimes a conclusion may be introduced by words such as "therefore", "thus", "it follows that". However, sometimes a conclusion may not contain any such word.

It is also important to note that a conclusion may appear at the beginning of, or in the middle of, an argument, rather than at the end.

For example, the above argument could have been written in this way:
We know Jill cannot attend the meeting. We are expecting a substitute. She promised she would attend the meeting or send a substitute.

Or in this way:
We are expecting a substitute for Jill. We know she cannot attend the meeting, and she promised she would attend or send a substitute.

In both these cases, "We are expecting a substitute (for Jill)" is the conclusion, because it is the statement which follows from, or is supported by, the rest of the passage.

Some arguments may omit a crucial stage in the reasoning - an assumption which must be made in order for the conclusion to follow. Here is an example:

She doesn't stand much of a chance. The polar bear is right behind her.

In this argument it is not explicitly stated that polar bears are dangerous, but the conclusion that "she doesn't stand much of a chance" depends upon the belief that polar bears are dangerous. This belief is taken for granted, or assumed.

In summary, the features of arguments are:
- reason(s)
- conclusion(s) (which may or may not be introduced by words such as "so", "therefore")
- assumption(s) i.e. crucial parts of the argument which have not been stated.

Arguments can be much more complex in structure than the examples given so far and they can be lengthy. But whatever their length and complexity, there are certain skills involved in understanding and evaluating arguments. These include: drawing and summarising conclusions, identifying assumptions and reasoning errors, and assessing the impact of additional evidence.

In the Critical Thinking category there are 7 different specific types of questions:

1. Summarising the main conclusion
2. Drawing a conclusion
3. Identifying an assumption
4. Assessing the impact of additional evidence
5. Detecting reasoning errors
6. Matching arguments
7. Applying principles

## 1. Summarising the Main Conclusion

In this type of question you have to judge which one of the statements A to E best expresses the main conclusion of the argument. So the first important step is to read the passage carefully and pick out the sentence which is the conclusion. Remember that the conclusion can appear anywhere within an argument – not necessarily at the end. Remember also that what you are looking for is the statement which follows from, or is supported by, the rest of the passage.

It may be helpful to ask yourself: "What is the main message which this passage is trying to get me to accept?" When you think you have answered this question, underline the sentence which expresses this main message, then look to see if the rest of the passage gives you reasons for believing this. Sometimes a passage may have an intermediate conclusion which is just one of the steps in the reasoning towards the main conclusion. Be careful to check this. If the sentence you have underlined gives reason to believe some other statement in the passage, then it will not be the main conclusion. Do not worry about whether the reasons are true. Just ask yourself: "If these reasons were true, would they give me good reason to accept the sentence I have underlined?"

Vegetarian food can be healthier than a traditional diet. Research has shown that vegetarians are less likely to suffer from heart disease and obesity than meat eaters. Concern has been expressed that vegetarians do not get enough protein in their diet but it has been demonstrated that, by selecting foods carefully, vegetarians are able to amply meet their needs in this respect.

Which one of the following best expresses the main conclusion of the above argument?

**A** A vegetarian diet can be better for health than a traditional diet.
**B** Adequate protein is available from a vegetarian diet.
**C** A traditional diet is very high in protein.
**D** A balanced diet is more important for health than any particular food.
**E** Vegetarians are unlikely to suffer from heart disease and obesity.

What does this argument seem to be trying to get us to accept? It seems to be trying to persuade us that vegetarian food can be healthier than a traditional diet, so we should underline the first sentence. Then we need to see whether the rest of the passage gives us reason to believe this. Two reasons are given:

1. Vegetarians are less likely to suffer from heart disease and obesity than meat eaters.
2. A vegetarian diet can contain sufficient protein.

We may not know whether these reasons are true, but if they were true, they would indicate that vegetarian food is healthier in one respect than a traditional diet which includes meat, and that a vegetarian diet does not necessarily have the disadvantage to health (providing insufficient protein) which we may have thought. So it seems clear that the first sentence of the passage is being offered as a conclusion.

**A** is the statement which best expresses this conclusion.

B is not the main conclusion, but it is one of the reasons for the main conclusion – labelled above as reason (2).

C is not the main conclusion, because it is not even stated in the passage. It is taken for granted that a traditional diet provides enough protein, but even this is not explicitly stated.

D is not the main conclusion, as it is not stated in the passage. No attempt is made to define a balanced diet. The passage simply makes a comparison between a traditional diet and a vegetarian diet.

E is not the main conclusion, but it is close in meaning to one of the reasons for the main conclusion – labelled above as reason (1).

## 2. Drawing a Conclusion

In this type of question candidates are asked which conclusion follows from the information given. You need to consider each of the statements A to E, and to think about whether the information in the passage gives you good reasons to accept the statement.

Ecotourism now accounts for twenty per cent of tourists. It should provide a sustainable alternative to overuse of natural resources. However, tourists may introduce new diseases to animal populations. Mongooses and meerkats in Botswana have died from tuberculosis caught from humans, and gorillas in East Africa picked up new internal parasites after the introduction of tourism. Moreover, the presence of humans in increased numbers has been shown to stress polar bears, penguins, dolphins and rainforest birds, affecting their natural routines and reducing breeding success.

Which one of the following conclusions can be drawn from the passage?

**A** Subtle changes to wildlife health may not be apparent to a casual observer.
**B** Many ecotourist projects are ecologically viable.
**C** Dolphins become increasingly frenetic when tourist boats are present.
**D** Guidelines for ecotourism mostly address obvious issues such as changes in land use or cutting down trees.
**E** The benefits of sustainable resources may be outweighed by harm to wildlife.

The correct answer is **E**. The main argument in the passage is stated at the beginning: “Ecotourism now accounts for twenty per cent of tourists. It should provide a sustainable alternative to overuse of natural resources.” Two reasons are given:

1. Tourists may introduce new diseases to animal populations. Mongooses and meerkats in Botswana have died from tuberculosis caught from humans, and gorillas in East Africa picked up new internal parasites after the introduction of tourism.
2. The presence of humans in increased numbers has been shown to stress polar bears, penguins, dolphins and rainforest birds, affecting their natural routines and breeding success.

From these premises, it follows that ecotourists could endanger the survival of the very wildlife they want to see (answer **E**).

A This is a difficulty in detecting damage done by ecotourism rather than a conclusion which follows from the reasoning in the passage.

B If the aim of ecotourism is to be achieved as stated in the second sentence of the passage giving the context of the argument, this ought to be true. However, the passage gives evidence that some ecotourist projects are not ecologically viable and this distractor is thus the diametric opposite of the conclusion which can be drawn from the reasoning.

C This would function as evidence to support the second reason.

D This is apparently true in some places but cannot be inferred from the passage.

### 3. Identifying an Assumption

An assumption is something which is not stated in the argument, but which is taken for granted in order to draw the conclusion. So you need first to identify the conclusion of the argument. Then look for the reasoning it gives to support this conclusion, and think about any important point which is not actually stated in the reasoning.

Many drivers deliberately break traffic laws, both because they are convinced that there is little chance of getting caught and because, even if they are caught, the penalties do not act as a sufficient deterrent. For example, people who would never think of stealing money even when they needed it, think nothing of routinely exceeding a 30 mph limit even in a street where children are playing. It is clear, then, that a substantial reduction in road accidents can be achieved only by catching more motorists who break the law and by increasing the penalties for such law-breakers.

Which one of the following is an underlying assumption of the above argument?

**A** The number of road accidents is increasing because motorists are ignoring the traffic laws.
**B** Drivers who have been convicted of a traffic offence think nothing of continuing to break the law.
**C** People who break the traffic laws are a significant cause of road accidents.
**D** If the penalties for stealing were less severe, people would think nothing of stealing money when they needed it.
**E** If the penalties for traffic offences were increased, drivers would not break the law so frequently.

In this case, **C** is the correct answer. The reasoning is as follows:

Reason 1: Many drivers deliberately break traffic laws, because they are convinced that there is little chance of getting caught, and because, even if they are caught, the penalties do not act as a sufficient deterrent.
Reason 2: People who would never think of stealing money even when they needed it, think nothing of routinely exceeding a 30 mph limit even in a street where children are playing.

Conclusion: A substantial reduction in road accidents can be achieved only by catching more motorists who break the law and by increasing the penalties for such law-breakers.
One assumption here is that a substantial number of accidents are caused by breaches of the traffic law: otherwise the conclusion would not follow.

A There is no need to assume that the number of accidents is increasing, only that they are high (because of breaking the law). It could be that they are falling, but are still too high.

B The argument is about lack of deterrence in general. There is no need to assume that being convicted does not deter drivers from reoffending.

D It is implied in the passage that people are more wary of stealing than of driving offences and that this may be due to higher penalties. However nothing as strong as D needs to be assumed for the comparison in the argument to support the conclusion.

E The argument is that two factors combine to make drivers careless about breaking traffic laws – being caught and light penalties. E is an assumption about penalties only and therefore the argument does not depend on it. Indeed, if E were assumed the argument would fail, because being caught would not be a necessary condition.

### 4. Assessing the Impact of Additional Evidence

This type of question will typically ask you to consider what would weaken or strengthen an argument. You need first to be clear about what the argument is trying to establish. Work out what the conclusion is, and then consider what effect each of the possible answers would have on the conclusion.

Here you are asked to consider what would weaken the argument:

Polar bears in captivity frequently engage in obsessive patterns of behaviour, pacing back and forth on the same spot, swinging their heads from side to side, and other signs of stress. They do this even when their living areas are quite spacious. What this shows is that conditions of captivity are not a satisfactory substitute for the natural environment of the polar bear species.

Which one of the following, if true, would most weaken the above argument?

**A** Polar bears are especially ill-suited to a life in captivity.
**B** Many polar bears in the wild engage in obsessive patterns of behaviour.
**C** Polar bears in captivity are much better fed than those living in the wild.
**D** Polar bears in the wild cover many miles a day when they are hunting for food.
**E** Polar bears which have been reared in captivity are incapable of surviving in the wild.

The answer is **B**. The conclusion of the argument is that the obsessive behaviour of polar bears in zoos shows that conditions of captivity are not a satisfactory substitute for the polar bear's natural environment. But if B is true, that is, if polar bears in the wild behave in the same way as those in captivity, then the behaviour of those in captivity cannot be taken as good evidence that the conditions of captivity are unsatisfactory.

A does not weaken the argument. If polar bears are ill-suited to a life in captivity, it follows that captivity is not a satisfactory substitute for their natural environment. So A strengthens the argument.

C does not weaken the argument, even though it suggests that polar bears might be better off in one respect in captivity (i.e., better fed). Captivity might nevertheless lead to stress which is not suffered by polar bears in the wild.

D does not weaken the argument, because even if polar bears cover many miles per days in the wild, pacing around in captivity may not be a satisfactory substitute for this freedom to roam.

E does not weaken the argument, because the conclusion is about the best environment for the polar bear species. Information about the best environment for those polar bears which have been reared in captivity cannot weaken this general conclusion about the species as a whole.

Here you are asked to consider what would strengthen the argument:

If children are sitting in rows in a classroom, the teacher can have eye contact with all of them while she is explaining something to them. This is not always possible if they are sitting in groups around tables. Also, when they look up, instead of seeing the child opposite in a group and being tempted to talk, they see the teacher. So, sitting in rows helps children to concentrate better on their work and should therefore be the standard arrangement in every school classroom.

Which one of the following, if true, would most strengthen the above argument?

**A** Rows of desks take up no more classroom space than tables.
**B** Some children are easily distracted whether they sit in rows or in groups.
**C** Sitting in groups of between four and seven makes discussion work easier.
**D** Traditionalists argue that teaching the whole class in rows is best.
**E** If desks are arranged in rows, children can all see visual aids more easily.

The conclusion is that rows of desks should be the standard arrangement in every school classroom. It is supported directly by the claim that this helps the children to concentrate, with the argument that children in groups will look up and see other children and so be tempted to talk with them, whereas sitting children in rows means they can only make eye-contact with their teacher.

**E** suggests that as well as being able to concentrate better, for reasons R1-3, rows allow visual aids to be seen better. This is a further reason for having desks in rows. Therefore **E** strengthens the argument and is the correct answer.

Whereas:

A neither weakens nor strengthens the argument as how much space is taken up is not a reason for coming to the conclusion.

B does not say whether these particular children would concentrate better in rows or not and so neither strengthens nor weakens the argument.

C actually weakens the argument by showing that some classroom work is easier when children are not in rows.

D, while aiming to support the conclusion, does not in itself provide evidence which would strengthen the argument as the views of traditionalists are not in themselves a reason for accepting the truth of the claim.

## 5. Detecting Reasoning Errors

This type of question asks you to identify the flaw in the argument, which means that you must explain why the conclusion does not follow from the reasons which are given. So you need to be clear about what the conclusion is, and what reasons are meant to support it.

Some people attempt to smuggle a pet into Britain because of the quarantine regulations which are aimed at preventing rabies from entering the country. If there were no such regulations, there would be no reason to smuggle pets. Since the most likely source of a rabies outbreak in Britain is a smuggled pet, if the quarantine regulations were abolished, the danger of a rabies outbreak would be reduced.

Which one of the following best describes the flaw in the argument?

**A** Rabies is not likely to enter Britain in a wild animal.
**B** The quarantine regulations cannot prevent owners from smuggling their pets.
**C** If there were no quarantine regulations, pets with rabies could enter Britain easily.
**D** If people did not want to travel with their pets, there would be no need for quarantine regulations.
**E** If pets were inoculated against rabies, there would be no need for quarantine regulations.

The answer is **C**. The argument draws the conclusion that if quarantine regulations were abolished, there would be less likelihood of an outbreak of rabies. The reasoning offered in support of this is that:

1. smuggled pets are the most likely source of an outbreak of rabies; and
2. if there were no quarantine regulations, no-one would be tempted to smuggle pets into Britain.

But the conclusion does not follow, because if there were no quarantine regulations, smuggled pets would no longer be the most likely cause of a rabies outbreak. Instead, the most likely cause would be pets which could be brought in without breaking any law. C is the statement which best explains this.

A does not describe the flaw, because it simply states something with which the argument would agree.

B does not describe the flaw, because it states something which the argument depends on – the idea that quarantine regulations cannot prevent outbreaks of rabies.

D does not describe the flaw, because it concerns the reason why quarantine regulations are thought to be necessary, rather than the consequences of getting rid of these regulations.

E does not describe the flaw, because it does not mention what would happen if quarantine regulations were abolished. Instead, it suggests a way to make them unnecessary, whilst still being able to prevent an outbreak of rabies.

## 6. Matching Arguments

This type of question asks you about similarity between arguments, but not the sort of similarity where two arguments are about the same topic. The similarity you are looking for is in the structure or the pattern of the argument.

I cannot get any answer when I dial my mother's number. Either she is not answering her phone or she has decided to stay away on holiday for an extra week. She must still be away. She would never let the phone ring without answering it.

Which one of the following most closely parallels the reasoning used in the above argument?

**A** If I want to remain fit and healthy I have to watch my diet and take exercise. I want to stay fit so I eat carefully and go running regularly.
**B** If Denise had carried on going to the gym and eating sensibly, she would never have got so run down. She did get run down, so she must either have given up her diet or stopped going to the gym.
**C** Joe is looking a lot fitter. Either he has cut down on his eating or he has been out running every day. I know for a fact that Joe couldn't keep to a diet, so it must be exercise that's done it.
**D** Anyone who swims over twenty lengths a day has to be pretty fit. Sheena swims thirty lengths a day. Therefore Sheena must be quite fit.
**E** Sticking to a diet is hard at first but after about two weeks most people get used to it. I have been dieting for nearly two weeks so I should be getting used to it soon.

As a first step to finding the structure in this argument, look at the passage to see if there are repeated statements which you could represent with a letter (e.g. X or Y). It is slightly difficult to do that in this argument, because the repeated statements are worded in a slightly different form each time. But we can see that there are two important ideas which are mentioned twice:

My mother is (must be) away.
My mother is not answering the phone (is letting the phone ring without answering it).
If we replace these statements with X and Y, we can see the following structure.

Either X is true or Y is true.
Y cannot be true.
So X must be true.
X = my mother is away.
Y = my mother is letting the phone ring without answering it.

We now have to look for the argument which has this same structure.
**C** is the answer. In this case X = Joe is exercising, Y = Joe is dieting, and the structure is the same:
Either X (Joe is exercising) or Y (Joe is dieting).
Y (Joe is dieting) cannot be true.
So X (Joe is exercising) must be true.

A has a different structure:
If I want X, I have to do Y.
I want X.
So I do Y.
X = remain fit (and healthy).
Y = watch my diet and take exercise.

B has a different structure:
If X and Y had happened, Z would not have happened.
Z did happen.
So either X didn't happen or Y didn't happen.
X = Denise going to gym.
Y = Denise eating sensibly.
Z = Denise getting run down.

D has a different structure:
All people who do X are Y.
Sheena does X.
Therefore Sheena is Y.
X = swim over 20 lengths a day.
Y = fit.

E has a different structure:
Most people who do X, succeed in Y.
I have done X.
So I should succeed in Y.
X = stick to a diet for 2 weeks.
Y = getting used to the diet.

## 7. Applying Principles

When you are asked which statement illustrates the principle underlying the passage, you must first identify this principle. A principle is a general recommendation, which, in the passage, will be applied to just one particular case, but which could also be applied to other cases. For example, someone might use the principle "Killing is wrong" in order to argue for pacifism, i.e. for refusing to go to war. If we are to accept the principle that killing is wrong, then it also follows that capital punishment is wrong, and even that killing in self-defence is wrong. In order to answer this type of question, you first need to understand the argument, so look for the conclusion, and for the reasons, in the usual way. This should enable you to see what principle the argument relies on in order to draw its conclusion. You then need to consider each possible answer to see which one follows from the principle.

Smokers who suffer from heart disease which is caused by their smoking should not be allowed to get free health treatment. That is because this is an example of self-inflicted illness. Those whose actions have caused illness or injury to themselves should make a financial contribution to their treatment.

Which one of the following best illustrates the principle underlying the argument above?

**A** Children should get free dental treatment, even if they eat sweets which cause dental decay.
**B** Heart disease sufferers who can afford to pay for health treatment should not receive free treatment.
**C** Smokers who cannot afford to pay for health care should be allowed free treatment when they are ill.
**D** People who are injured in car accidents should receive free treatment regardless of whether they were wearing a seat belt.
**E** Motor cyclists whose head injuries are caused by not wearing a crash helmet should make a financial contribution to their treatment.

The conclusion of this argument is that smokers who get heart disease as a result of smoking should not get free health treatment. The reason given for this is that their illness is self-inflicted. This reasoning relies on the general principle that if your actions have caused your illness or injury, you should make a financial contribution to your treatment. The correct answer is **E**, which applies the principle to motor cyclists whose failure to wear a crash helmet has caused their head injuries.

A is not an application of the principle, because it suggests that even if a child's actions (eating sweets) have caused a health problem (dental decay), the child should nevertheless have free treatment.

B is not an application of the principle, because it makes a recommendation based on people's ability to pay for treatment, rather than on whether their actions have caused their illness.

C is not an application of the principle, because, like B, it makes its recommendation solely on the ability to pay.

D is not an application of the principle because it recommends free treatment regardless of whether people's actions have contributed to their injuries.

## Section 2: Biology

In accordance with the Ministerial Program for secondary schools, the biology section of IMAT covers all the following topics:

**The chemistry of living things**

The biological importance of weak interactions. Organic molecules in organisms and their respective functions. The role of enzymes.

**The cell as the basis of life**

Cell theory. Cell size. Prokaryotic and eukaryotic cells, animal and plant cells. Viruses.
The structure and function of the cell membrane and transport across the membrane. Cellular structures and their specific functions. Cell cycle and cell division: mitosis and meiosis - chromosomes and chromosome maps.

**Bioenergetics**

The energy currency of cells: ATP. Redox reactions in living things. Photosynthesis, glycolysis, aerobic respiration and fermentation.

**Reproduction and Inheritance**

Life cycles. Sexual and asexual reproduction. Mendelian genetics: Mendel's laws and their applications. Classical genetics: chromosomal theory of inheritance - inheritance patterns. Molecular genetics: structure and replication of DNA, the genetic code, protein synthesis. Prokaryotic DNA. Eukaryotic chromosome structure. Genes and regulation of gene expression.
Human genetics: mono- and multifactorial character transmission; hereditary diseases - autosomal and linked to chromosome X.
Biotechnology: recombinant DNA technology and its applications.

**Inheritance and environment**

Mutations. Natural and artificial selection. Evolutionary theories. The genetic basis of evolution.

**Anatomy and physiology of animals and humans**

The animal tissues. Anatomy and physiology of systems in humans and their interactions. Homeostasis.

**EXAMPLE 1:**

Having hairy ears is due to a gene found only on the Y chromosome. Assuming that 1% of Y chromosomes have this gene, which answer shows the likely number of people with hairy ears in a population of 10 000?

**A** 50
**B** 100
**C** 500
**D** 1000
**E** 5000

The correct answer is **A**. In a population of 10 000, about half will be male and hence will carry the Y chromosome. 1% of the male population of 5000 is 50, hence A is correct.

B - this is 1% of 10 000
C - this is 10% rather than 1% of 5000
D - this is 10% of the whole population
E - gives the number of males in the population

**EXAMPLE 2:**

Which one of the following is NOT true of human hormones?

**A** They are all released from glands and flow down ducts into the bloodstream.
**B** They are all chemicals.
**C** Some, such as testosterone and oestrogen, can be steroids.
**D** They travel at the speed of blood flow.
**E** A hormone may affect one or more structures in the body.

The answer is **A** because, whilst hormones are released from glands, they do not travel down ducts but are released directly into the blood stream.

B - hormones are indeed chemicals
C - the sex hormones named are steroid hormones
D - as they travel in the blood plasma, they will travel at blood plasma speed
E - a number of hormones have multiple and diffuse functions within the body

**EXAMPLE 3:**

In a DNA sample, the percentage of guanine present was 28%. What is the percentage of thymine in the sample?

**A** 22%
**B** 27%
**C** 28%
**D** 44%
**E** 54%

The percentage of adenine, guanine cytosine and thymine should be 100%. As guanine is 28% and always binds with cytosine, then cytosine must be 28%. The remainder, 44%, is made up of equal amounts of thymine and adenine hence thymine = 44 ÷2 or 22% which is answer **A**.

B - this would incorrectly imply that guanine was present as 23% rather than 28%
C - this is the answer for cytosine
D - this is the answer for adenine and thymine together
E - this could be a miscalculated value for guanine and cytosine

## Section 3: Chemistry

In accordance with the Ministerial Program for secondary schools, the chemistry section of IMAT covers all the following topics:

**The composition of matter**

States of matter; heterogeneous and homogeneous systems; compounds and elements. Ideal Gas Laws.

**Atomic structure**

Elementary particles; atomic number and mass number, isotopes, electronic structure of atoms of different elements.

**The periodic table of the elements**

Groups and periods; transition elements. Periodic properties of elements: atomic radius, ionization potential, electron affinity, metallic character. The relationships between electronic structure, position in the periodic table, and element properties.

**The chemical bond**

Ionic, covalent and metallic bonds. Binding energy. Polarity of bonds. Electronegativity. Intermolecular bonds.

**Fundamentals of inorganic chemistry**

Nomenclature and main properties of inorganic compounds: oxides, hydroxides, acids, salts.

**Chemical reactions and stoichiometry**

Atomic and molecular mass, Avogadro's number, mole concept and its application, elementary stoichiometric calculations, balancing simple reactions, different types of chemical reaction.

**Solutions**

Solvent properties of water, solubility, the main ways of expressing the concentration of solutions. Equilibria in aqueous solution. Chemical kinetics and catalysis.

**Oxidation and reduction**

Oxidation number, concept of oxidizing and reducing. Balancing of simple reactions.

**Acids and bases**

The concept of acid and base. Acidity, neutrality and basicity of aqueous solutions. The pH scale. Hydrolysis. Buffer solutions.

**Fundamentals of organic chemistry**

Bonds between carbon atoms, and crude formulas of structure, the concept of isomerism. Aliphatic, alicyclic and aromatic hydrocarbons. Functional groups: alcohols, ethers, amines, aldehydes, ketones, carboxylic acids, esters, amides. Chemical nomenclature.

**EXAMPLE 1:**

Which of the following statements are correct about the solvent properties of water?

1. All ionic substances dissolve in water.
2. All covalent substances are insoluble in water.
3. The solubility of solids usually increases with a rise in temperature.

**A** 3 only
**B** 1 only
**C** 2 only
**D** 2 and 3
**E** none

The correct answer is **A**.
This question assesses the accuracy of your conceptual understanding of solubility; in this question it is a problem solving process of thinking about counter-examples that is most productive. Not all ionic substances are soluble in water, for example lead (II) sulfide, or strontium carbonate so statement 1 is not correct.

Statement 2 is not correct, for example sucrose, ethanol, and water are all covalent and soluble in water. Of course water is infinitely soluble in water.

Statement 3 is true, for example barium nitrate. The correct option is: 3 only.

**EXAMPLE 2:**

Which of the following must be correct about organic isomers?

1. They have the same molecular formulae
2. Their physical properties are very similar
3. They have different structural formulae.

**A** 1 and 3 only
**B** 1 only
**C** 1 and 2 only
**D** 2 and 3 only
**E** 1, 2 and 3

The correct answer is **A**. For this question, you should be thinking not what is typical, but what is necessary – a key attribute of a proficient scientist. Organic isomers have the same number of atoms of each species present, but they are in different arrangements.

So the molecular formula has to be the same for a given set of isomers, since the number of atoms of each species must, by definition, be the same.

The structural formula must, by definition, be different, since the atoms are structurally in different locations in each isomer.

Isomers do not have to have similar physical properties. For example, methyl propane has a much lower boiling point that butane. Therefore the correct response is: 1 and 3 only.

**EXAMPLE 3:**

An oxide of iron has the formula $Fe_3O_4$ and contains both $Fe^{2+}$ e $Fe^{3+}$ ions.

Which one of the following is the fraction of iron ions that are in the $Fe^{2+}$ state?

**A** $^1/_3$
**B** ¼
**C** ½
**D** $^2/_3$
**E** ¾

The correct answer is **A**. For this question you may not know how to start it. It can be useful to simply start by trying a few values to get a sense of the structure of the problem, and then changing the values to see what happens – this is a common strategy that is effective for some questions.

In $Fe_3O_4$, all four oxygens give rise to an oxidation number of $4 \times -2 = -8$, there are three iron atoms, the oxidation numbers of which need to add up to +8, in order for the formula to be correct, the only way to do this is to have $2Fe^{3+}$ and $1Fe^{2+}$, so one iron atom is in the $Fe^{2+}$ state out of a total of 3 iron atoms, thus the fraction is 1/3.

**EXAMPLE 4:**

When molecules collide, for a reaction to take place, two conditions must be met. Firstly, they must have sufficient energy to react and secondly, they must have the right orientation. This means that the ends of the molecules that are going to react must be in contact with each other.

Raising the temperature speeds up a chemical reaction.

Which of the following could be responsible for this?

1. More collisions take place
2. The average collisions has more energy
3. The orientation of the molecules is more favourable.

**A** Only 1 and 2
**B** Only 1 and 3
**C** Only 2 and 3
**D** Only 2
**E** 1, 2 and 3

The right answer is **A**. This question expects you to relate chemistry on different scales, the microscopic and macroscopic – it assesses your conceptual understanding of temperature across different chemical models.

Statement 1 is valid: the higher the temperature, the faster the molecules move, and so the higher the frequency of collisions.

Statement 2 is valid: the higher the temperature, the faster the molecules move on average, so the kinetic energy of the molecules is higher on average, so the energy of the collisions is higher on average.

Statement 3 is not correct. Since the molecules have to be mobile to collide, they already have access to all orientations of molecules. Heating increases the speed of the mobile molecules, not the direction in which they collide with each other (orientation).

Therefore the correct response is: 1 and 2 only

**EXAMPLE 5:**

The equation for the preparation of nitrogen monoxide is:

$$aCu + bHNO_3 \rightarrow aCu(NO_3)_2 + cH_2O + 2NO$$

What is the value of b?

**A** 8
**B** 16
**C** 12
**D** 6
**E** 4

This is a very straightforward question, there is no easy way of ruling out incorrect response options – the only way to arrive at the correct answer is to work through the question.

This equation is balanced either by redox methods, or by ensuring that the number of atoms is the same for each species on both sides of the equation. To approach from an atom counting/problem solving approach and offer you something different from a solution typically taught in school:

From the equation, you can see that the only species to involve oxygen or nitrogen on the left is the nitrate ion, $NO_3^-$. On the right hand side of the equation, there are still nitrate ions in compound with copper, but there is also a nitrogen monoxide, and water – there is no oxygen or nitrogen anywhere else on the right hand side. The nitrogen and oxygen from the water and nitrogen monoxide combined must be in the ratio of 1:3, and must match that of the Nitrate ions from which it originated.

To achieve this, c must be 4. If c is 4, then there are 8 hydrogens on the right hand side. There must be 8 on the left hand side, so b must be 8. (The correct response.)

To fully balance the equation, the next step is to use your knowledge that b=8 on the nitrogens. There are 8 nitrogens on the left hand side, so there has to be 8 on the right, so a must be 3. Therefore the correct answer is **A**.

**EXAMPLE 6:**

The mass spectrum of boron shows two peaks with isotopic masses of 10.0 and 11.0.

The heights of the peaks indicate the relative proportion of each isotope. The heights of the peaks are in the ration of 18.7 % : 81.3 %.

What is the average atomic mass of boron?

**A** 10.81
**B** 10.19
**C** 10.32
**D** 10.48
**E** 10.67

This question can be calculated by using exact methods, however the numbers are not convenient and thus this approach will be too time-consuming. To progress through the question you will need to approximate the calculations in order to complete this in a reasonable time.

The ratio is approximately 20:80, which simplifies to 1:4. So for every 5 atoms, approximately one has a mass of 10, and 4 have a mass of 11.

The average mass is $\frac{10+4\times11}{5}=\frac{54}{5}=10\frac{4}{5}=10.8$

10.81 is closest to this estimate, and by exact calculation 10.81 is correct.

Therefore **A** = 10.81 is the correct response.

## Section 4: Mathematics and Physics

### Mathematics

In accordance with the Ministerial Program for secondary schools, the mathematics section of IMAT covers all the following topics:

**Algebra and numerical sets**

Natural numbers, integers, rational and real numbers. Sorting and comparison: scales and scientific notation. Operations and their properties. Proportions and percentages. Powers with integer and rational exponents, and their properties. Roots and their properties. Logarithms (base 10 and base *e*) and their properties. Elements of combinatorics. Algebraic and polynomial expressions. Major products and $n^{th}$ power of binomial expansions, factorisation of polynomials. Algebraic fractions. Algebraic equations and inequalities of the first and second order. Systems of equations.

**Functions**

Basic concepts of functions and their graphical representations (domain, codomain, sign, maximum and minimum, increasing and decreasing, etc.). Elementary functions: whole and fractional algebraic functions; exponential, logarithmic, and trigonometric functions. Composite and inverse functions. Trigonometric equations and inequalities.

**Geometry**

Polygons and their properties. Circle and circumference. Measurements of lengths, surfaces and volumes. Isometries, similarities and equivalences in the plane. Geometric loci. Measurement of angles in degrees and radians. Sine, cosine, tangent of an angle and their significant values. Trigonometric formulas. Solving triangles. Cartesian reference system in a plane. Distance between two points and the midpoint of a segment. Straight line equation. Conditions for parallel and perpendicular lines. Distance of a point to a line. Equation of the circle, the parabola, the hyperbola, the ellipse and their representation in the Cartesian plane. Pythagoras' theorem. Euclid's first and second theorems.

**Probability and statistics**

Frequency distributions and their graphical representations. Concept of random experiments and events. Probability and frequency.

**EXAMPLE 1:**

In a group of students 2/5 are male and exactly 1/3 studies mathematics. The probability that a male student chosen at random from the group studies mathematics is *p*.

Which of the following is the range of possible values of *p?*

**A** $0 \le p \le 5/6$
**B** $0 \le p \le 1/3$
**C** $1/3 \le p \le 2/5$
**D** $1/3 \le p \le 1$
**E** $2/5 \le p \le 5/6$

The correct answer is **A**. The first things to notice about this question are the inequalities, these are not generally studied in school courses, and that is because this is a non-routine question. It requires the use of problem solving strategies. In this question it is case of considering 'best' and 'worst' case scenarios.

The solution to this problem involves taking the two extremes:

1. That the number of males studying maths is maximised
2. That the number of males studying maths is minimised

Considering case 1:
The maximum number of males studying maths. In this case we could have all the maths students being male because $\frac{1}{3} < \frac{2}{5}$. Let's say there are $N$ students in total so that we are dealing with numbers rather than probabilities, then in this case the number of male students studying maths is $\frac{N}{3}$, and the number of male students is $\frac{2N}{5}$. The probability of a student from the set of male students studying maths is then $p = \frac{N}{3} \div \frac{2N}{5} = \frac{N}{3} \times \frac{5}{2N} = \frac{5}{6}$

Considering case 2:

Now we want to minimise the number of males students studying maths. So this means maximising the number of female students studying maths. $\frac{3}{5}$ of the group of students are female, so all the maths students could be female, because $\frac{1}{3} < \frac{3}{5}$. In this case none of the male students study maths, $p = 0$.

The actually probability can lie anywhere between and inclusive of these values:
$0 \le p \le \frac{5}{6}$.
The correct answer is **A**.

**EXAMPLE 2:**

A cuboid stands 9 cm tall.

The base of the cuboid is square, with a side length of 6 cm. The vertices of the base are denoted ABCD in anticlockwise order such that B and D are diagonally opposite each other. The vertex that is directly above A is denoted E.

What is the tangent of the angle that the triangle BDE makes with the horizontal base?

**A** $\frac{3}{\sqrt{2}}$

**B** $\frac{\sqrt{2}}{3}$

**C** $\frac{\sqrt{3}}{2}$

**D** $\frac{2}{\sqrt{3}}$

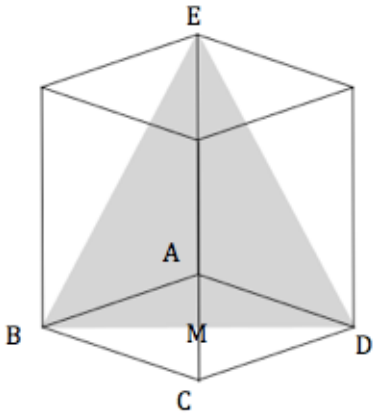
**E** $3\sqrt{2}$

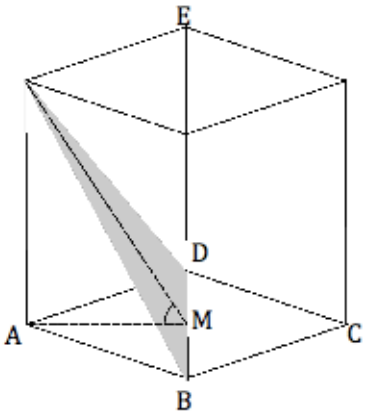
The correct answer is **A**. The first thing to do for this question is present this information in a handy way to solve the problem. With this being a geometry question, the best way is probably to draw one or more diagrams – this can really help you visualise the problem.

After that, it is a case of asking yourself:
What do I know?
What do I want?
What can I calculate to get me closer to the final solution?
Can I break-up the question into stages?

The mathematical reasoning is given below.

Side-on and face-on diagrams for the system are given below:




The angle required is AME, where M is the midpoint of BD and AC.

All the vertices of the object are right angles because it is a cuboid, so we can apply Pythagoras' theorem to calculate BD = AC = $6\sqrt{2}$ cm.

Thus AM = $3\sqrt{2}$ cm.

Hence $\tan(AME) = \frac{AE}{AM} = \frac{9}{3\sqrt{2}} = \frac{3}{\sqrt{2}}$ and so the correct response is $\frac{3}{\sqrt{2}}$.

**EXAMPLE 3:**

| A human blood cell is approximately 8 x$10^{-4}$ centimetres.<br><br>How many of them placed side by side in a single straight line would be needed to cover 1 kilometre? | |
|---|---|
| **A** | 1.25 × $10^{8}$ |
| **B** | 8 × $10^{16}$ |
| **C** | 1.25 × $10^{6}$ |
| **D** | 1.25 × $10^{7}$ |
| **E** | 8 × $10^{9}$ |

The correct answer is **A**. This question really assesses familiarity with scientific notation and unit conversion.

This can really cause confusion at times, especially with the exponents of 10, so at this point a safer way to approach it is to:

Think about the question, if the blood cells were 2 cm in diameter and we wanted to find out how many fitted in a length of 1 metre. We would express 1 metre as 100 cm, and divide it by the diameter to get 50.

It is just the same for this, but now the numbers are in more challenging units and in scientific notation.

1 km = $10^{5}$ cm

Let $n$ be the number of blood cells that fit:

$$n = \frac{10^5}{8 \times 10^{-4}} = \frac{10^9}{8} = \frac{10 \times 10^8}{8} = \frac{10}{8} \times 10^8 = 1.25 \times 10^8$$

Thus the correct answer is $1.25 \times 10^8$ .

## Physics

In accordance with the Ministerial Program for secondary schools, the physics section of IMAT covers all the following topics:

### Measures

Direct and indirect measures, fundamental and derived quantities, physical dimensions of quantities, knowledge of the metric system and the CGS System of Units, Technical (or practical) (ST) and International System (SI) units of measurement (names and relationships between fundamental and derived units), multiples and sub-multiples (names and values).

### Kinematics

Kinematic quantities, various types of motion with particular regard to uniform and uniformly accelerating rectilinear motion; uniform circular motion; harmonic motion (for all motions: definition and relationships between quantities).

### Dynamics

Vectors and vector operations. Forces, moments of forces about a point. Moment of a force couple. Vector composition of forces. Definition of mass and weight. Acceleration due to gravity. Density and specific gravity. The law of universal gravitation, 1st, 2nd and 3rd laws of motion. Work, kinetic energy, potential energy. Principle of conservation of energy. Impulse and momentum. Principle of conservation of momentum.

### Fluid mechanics

Pressure, and its unit of measure (not only in the SI system). Archimedes' Principle. Pascal's principle. Stevino's law.

### Thermodynamics

Thermometry and calorimetry. Specific heat, heat capacity. Mechanisms of heat propagation. Changes of state and latent heats. Ideal Gas Laws. First and second laws of thermodynamics.

### Electrostatic and electrodynamics

Coulomb's law. Electric field and potential. Dielectric constant. Capacitors. Capacitors in series and in parallel. Direct current. Ohm's Law. Kirchhoff's Principles. Electrical resistance and resistivity, electrical resistances in series and in parallel. Work, Power, Joule effect. Generators. Electromagnetic induction and alternating currents. Effects of electrical currents (thermal, chemical and magnetic).

**EXAMPLE 1:**

A block of iron at 100˚C is transferred to a plastic cup containing water at 20˚C.

Which one of the following is NOT necessary in order to find the specific heat capacity of iron?

**A** The thermal conductivity of the iron.
**B** The mass of water.
**C** The final temperature.
**D** The mass of the block of iron.
**E** The specific heat capacity of water.

The correct answer is **A**. The first thing to ask is what do you know about specific heat capacity and what it depends on? In this case there is a formula that describes the relationship between the necessary quantities.

The specific heat capacity of the iron block $C = \frac{\Delta Q}{m \cdot \Delta T}$, where $\Delta Q$ is the amount of heat transferred into the block, $\Delta T$ is the change in temperature of the iron block and $m$ is the mass of the block.

In order to calculate the amount of heat transferred from the water to the block, use the same equation, but this time for the water, and with the change in heat as the subject: $\Delta Q = C \cdot m \cdot \Delta T$

The value of ΔQ is the same for both substances, as the heat lost by the iron block is the same as the heat gained by the water.

In order to complete the calculation the following are therefore needed:

- Initial and final temperatures of the iron and water
- Specific heat capacity of water
- Mass of iron
- Mass of water

We do not need the thermal conductivities of either substance.

**EXAMPLE 2:**

A bullet of mass 50 g is fired from a rifle with a velocity of 300 m/s. It hits a bank of earth and after travelling 60 cm into the bank comes to rest.

What is the average stopping force of the earth in the bank on the bullet?

**A** $3.75 \times 10^3$ N
**B** 3.75 N
**C** 37.5 N
**D** $3.75 \times 10^4$ N
**E** $3.75 \times 10^6$ N

The correct answer is **A**. The key questions to ask are: what do I know?
What do I want? What can I deduce or calculate to bridge that gap?

In this case one approach arises from:

- knowing that energy is conserved, and so the work done against the bank is the same as the bullet's initial kinetic energy
- knowing how to calculate the kinetic energy, from the mass and speed of the bullet
- knowing how to relate work done, force and distance travelled.

As ever it is important to be mindful of units. Notice that the options have S.I. units of Newtons, and so all quantities used in this question should be in S.I. units. This means we need to convert the mass of the bullet from 50 g into 0.05 kg. We also need to convert the distance of 60 cm into 0.6 m.

The loss of energy of the bullet is the work done by it on the bank. Assuming the bullet travels horizontally, the loss of energy of the bullet is the same as the loss of its kinetic energy ($\frac{1}{2}mv^2$).

The loss of kinetic energy is $\frac{1}{2}\cdot 0.05\cdot 300^2 = \frac{1}{2}\times\frac{1}{20}\times 90000 = \frac{9000}{4} = 2250\text{J}$
This is the same as the work done on the bank.
Now assuming that the bullet travels in a straight line through the bank, in the same direction as its initial motion, the work done is given by the product of the average force and distance travelled.

Hence, the average force in Newtons is given by work done divided by distance travelled:
$\overline{F} = \frac{2250}{0.6} = \frac{2250}{1}\div\frac{3}{5} = \frac{2250}{1}\times\frac{5}{3}$.

This divisor of 3 is quite tricky, it might be easier to write 2250 as $\frac{9000}{4}$:
$\overline{F} = \frac{9000}{4}\times\frac{5}{3} = \frac{3000}{4}\times 5 = \frac{15000}{4} = \frac{7500}{2} = 3750 = 3.75\times 10^3$ N

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