

ECONOMICS ADMISSIONS ASSESSMENT (ECAA)

Content Specification

For assessment in 2021

Overview

The Economics Admissions Assessment consists of two sections:

Section 1: A multiple-choice assessment, comprising approximately 20 Mathematics questions and 20 Advanced Mathematics questions.

The time allowed for Section 1 is 60 minutes.

Section 2: An extended essay responding to an excerpt from a text.

The time allowed for Section 2 is 60 minutes.

The purpose of the Economics Admissions Assessment is to determine a candidate's potential to achieve in an academically demanding undergraduate degree course. Questions draw upon a candidate's ability to use and apply their reasoning and mathematical knowledge, but require their application in possibly unfamiliar contexts. The assessment is designed to be challenging in order to differentiate effectively between able applicants, including those who might have achieved the highest possible grades in school examinations.

Format

Section 1: A 60-minute assessment, consisting of 40 multiple-choice questions. This section is in two parts:

Part A Mathematics (20 questions)

Part B Advanced Mathematics (20 questions).

It is strongly recommended that candidates spend 30 minutes on Part A and 30 minutes on Part B. Results for each part will be reported separately.

Candidates will require a soft (HB) pencil for this section, and will be issued with a separate answer sheet on which to indicate their answers.

Calculators and dictionaries may NOT be used in Section 1.

Section 2: A 60-minute assessment. Candidates will be asked to read a short passage of 1-2 pages and then to write an essay in answer to a question, drawing on the material in the passage and any other ideas that they consider relevant.

Candidates will require a black pen for this section, and will be issued with an answer booklet in which they will be required to write out their answer.

Calculators and dictionaries may NOT be used in Section 2.

Example questions for Section 1 and Section 2 are given in Appendix 2.

Content

Section 1

The questions in Section 1 Part A (Mathematics) will draw upon the topics listed as Mathematics (labelled 'M') in Appendix 1.

The questions in Section 1 Part B (Advanced Mathematics) will draw upon the topics listed as Advanced Mathematics (labelled 'AM') in Appendix 1. Section 1 Part B will also assume knowledge of all content in Section 1 Part A.

Section 2

Section 2 will relate to a topic of economic interest (broadly defined). This section of the assessment does not require any knowledge of the specific techniques of economic analysis or factual information about the economy of a particular country.

An example of an essay question from Section 2 is given in Appendix 2.

Scoring

In Section 1, each correct answer will score 1 mark. No marks are deducted for incorrect answers. Results for Part A and Part B will be reported **separately**.

In Section 2, the candidate's essay will be assessed by taking into account the quality of the candidate's reasoning, and their ability to construct a reasoned, insightful and logically consistent argument with clarity and precision.

APPENDIX 1: KNOWLEDGE ASSUMED IN SECTION 1

The material that follows outlines the mathematical knowledge assessed in Section 1 of the Economics Admissions Assessment.

Mathematics	(topics labelled 'M')
Advanced Mathematics	(topics labelled 'AM')

Questions in Section 1 Part A (Mathematics) will be based around topics labelled 'M'.

Questions in Section 1 Part B (Advanced Mathematics) will be primarily based around topics labelled 'AM', but it will also be assumed that candidates are familiar with the Part A: Mathematics topics labelled 'M'.

Throughout this specification, it should be assumed that, where mention is made of a particular quantity, knowledge of the SI unit of that quantity is also expected (including the relationship of the unit to other SI units through the equations linking their quantities).

Candidates will be expected to be familiar with the following SI prefixes when used in connection with any SI unit:

nano-	10^{-9}
micro-	10^{-6}
milli-	10^{-3}
centi-	10^{-2}
deci-	10^{-1}
kilo-	10^3
mega-	10^6
giga-	10^9

Candidates are expected to be familiar with the use of negative indices in units, for example m s^{-1} for velocity.

MATHEMATICS

M1. Units

- M1.1 Use standard units of mass, length, time, money and other measures.
Use compound units such as speed, rates of pay, unit pricing, density and pressure, including using decimal quantities where appropriate.
- M1.2 Change freely between related standard units (e.g. time, length, area, volume/capacity, mass) and compound units (e.g. speed, rates of pay, prices, density, pressure) in numerical and algebraic contexts.

M2. Number

- M2.1 Order positive and negative integers, decimals and fractions.
Understand and use the symbols: = , ≠ , < , > , ≤ , ≥ .
- M2.2 Apply the four operations (addition, subtraction, multiplication and division) to integers, decimals, simple fractions (proper and improper) and mixed numbers – any of which could be positive and negative.
Understand and use place value.
- M2.3 Use the concepts and vocabulary of prime numbers, factors (divisors), multiples, common factors, common multiples, highest common factor, lowest common multiple, and prime factorisation (including use of product notation and the unique factorisation theorem).
- M2.4 Recognise and use relationships between operations, including inverse operations.
Use cancellation to simplify calculations and expressions.
Understand and use the convention for priority of operations, including brackets, powers, roots and reciprocals.
- M2.5 Apply systematic listing strategies. (For instance, if there are m ways of doing one task and for each of these tasks there are n ways of doing another task, then the total number of ways the two tasks can be done in order is $m \times n$ ways.)
- M2.6 Use and understand the terms: *square*, *positive* and *negative square root*, *cube* and *cube root*.
- M2.7 Use index laws to simplify numerical expressions, and for multiplication and division of integer, fractional and negative powers.
- M2.8 Interpret, order and calculate with numbers written in standard index form (standard form); numbers are written in standard form as $a \times 10^n$, where $1 \leq a < 10$ and n is an integer.
- M2.9 Convert between terminating decimals, percentages and fractions.
Convert between recurring decimals and their corresponding fractions.
- M2.10 Use fractions, decimals and percentages interchangeably in calculations.
Understand equivalent fractions.

- M2.11 Calculate exactly with fractions, surds and multiples of π .
Simplify surd expressions involving squares, e.g. $\sqrt{12} = \sqrt{4 \times 3} = \sqrt{4}\sqrt{3} = 2\sqrt{3}$, and rationalise denominators; for example, candidates could be asked to rationalise expressions such as: $\frac{3}{\sqrt{7}}$, $\frac{5}{3+2\sqrt{5}}$, $\frac{7}{2-\sqrt{3}}$, $\frac{3}{\sqrt{5}-\sqrt{2}}$.
- M2.12 Calculate with upper and lower bounds, and use in contextual problems.
- M2.13 Round numbers and measures to an appropriate degree of accuracy, e.g. to a specified number of decimal places or significant figures.
Use inequality notation to specify simple error intervals due to truncation or rounding.
- M2.14 Use approximation to produce estimates of calculations, including expressions involving π or surds.

M3. Ratio and proportion

- M3.1 Understand and use scale factors, scale diagrams and maps.
- M3.2 Express a quantity as a fraction of another, where the fraction is less than 1 or greater than 1.
- M3.3 Understand and use ratio notation.
- M3.4 Divide a given quantity into two (or more) parts in a given *part:part* ratio.
Express the division of a quantity into two parts as a ratio.
- M3.5 Apply ratio to real contexts and problems, such as those involving conversion, comparison, scaling, mixing and concentrations.
Express a multiplicative relationship between two quantities as a ratio or a fraction.
- M3.6 Understand and use proportion.
Relate ratios to fractions and to linear functions.
- M3.7 Identify and work with fractions in ratio problems.
- M3.8 Define percentage as 'number of parts per hundred'.
Interpret percentages and percentage changes as a fraction or a decimal, and interpret these multiplicatively.
Express one quantity as a percentage of another.
Compare two quantities using percentages.
Work with percentages greater than 100%.
Solve problems involving percentage change, including percentage increase/decrease, original value problems and simple interest calculations.

- M3.9 Understand and use direct and inverse proportion, including algebraic representations.
Recognise and interpret graphs that illustrate direct and inverse proportion.
Set up, use and interpret equations to solve problems involving direct and inverse proportion (including questions involving integer and fractional powers).
Understand that x is inversely proportional to y is equivalent to x is proportional to $\frac{1}{y}$.
- M3.10 Compare lengths, areas and volumes using ratio notation.
Understand and make links to similarity (including trigonometric ratios) and scale factors.
- M3.11 Set up, solve and interpret the answers in growth and decay problems, including compound interest, and work with general iterative processes.

M4. Algebra

- M4.1 Understand, use and interpret algebraic notation; for instance: ab in place of $a \times b$; $3y$ in place of $y+y+y$ and $3 \times y$; a^2 in place of $a \times a$; a^3 in place of $a \times a \times a$; a^2b in place of $a \times a \times b$; $\frac{a}{b}$ in place of $a \div b$.
- M4.2 Use index laws in algebra for multiplication and division of integer, fractional, and negative powers.
- M4.3 Substitute numerical values into formulae and expressions, including scientific formulae.
Understand and use the concepts and vocabulary: *expressions, equations, formulae, identities, inequalities, terms* and *factors*.
- M4.4 Collect like terms, multiply a single term over a bracket, take out common factors, and expand products of two or more binomials.
- M4.5 Factorise quadratic expressions of the form x^2+bx+c , including the difference of two squares.
Factorise quadratic expressions of the form ax^2+bx+c , including the difference of two squares.
- M4.6 Simplify expressions involving sums, products and powers, including the laws of indices.
Simplify rational expressions by cancelling, or factorising and cancelling.
Use the four rules on algebraic rational expressions.
- M4.7 Rearrange formulae to change the subject.
- M4.8 Understand the difference between an equation and an identity.
Argue mathematically to show that algebraic expressions are equivalent.
- M4.9 Work with coordinates in all four quadrants.
- M4.10 Identify and interpret gradients and intercepts of linear functions ($y = mx + c$) graphically and algebraically.
Identify pairs of parallel lines and identify pairs of perpendicular lines, including the relationships between gradients.
Find the equation of the line through two given points, or through one point with a given gradient.

- M4.11 Identify and interpret roots, intercepts and turning points of quadratic functions graphically.
Deduce roots algebraically, and turning points by completing the square.
- M4.12 Recognise, sketch and interpret graphs of:
- linear functions
 - quadratic functions
 - simple cubic functions
 - the reciprocal function: $y = \frac{1}{x}$ with $x \neq 0$
 - the exponential function: $y = k^x$ for positive values of k
 - trigonometric functions (with arguments in degrees): $y = \sin x$, $y = \cos x$, $y = \tan x$ for angles of any size
- M4.13 Interpret graphs (including reciprocal graphs and exponential graphs) and graphs of non-standard functions in real contexts to find approximate solutions to problems, such as simple kinematic problems involving distance, speed and acceleration.
- M4.14 Calculate or estimate gradients of graphs and areas under graphs (including quadratic and other non-linear graphs), and interpret results in cases such as distance–time graphs, speed–time graphs and graphs in financial contexts.
- M4.15 Set up and solve, both algebraically and graphically, simple equations including simultaneous equations involving two unknowns; this may include one linear and one quadratic equation.
Solve two simultaneous equations in two variables (linear/linear or linear/quadratic) algebraically.
Find approximate solutions using a graph.
Translate simple situations or procedures into algebraic expressions or formulae; for example, derive an equation (or two simultaneous equations), solve the equation(s) and interpret the solution.
- M4.16 Solve quadratic equations (including those that require rearrangement) algebraically by factorising, by completing the square, and by using the quadratic formula.
Know the quadratic formula: $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$
Find approximate solutions of quadratic equations using a graph.
- M4.17 Solve linear inequalities in one or two variables.
Represent the solution set on a number line, or on a graph, or in words.
- M4.18 Generate terms of a sequence using term-to-term or position-to-term rules.
- M4.19 Deduce expressions to calculate the n^{th} term of linear or quadratic sequences.

M5. Geometry

- M5.1 Use conventional terms and notation: points, lines, line segments, vertices, edges, planes, parallel lines, perpendicular lines, right angles, subtended angles, polygons, regular polygons and polygons with reflection and/or rotational symmetries.
- M5.2 Recall and use the properties of angles at a point, angles on a straight line, perpendicular lines and opposite angles at a vertex.
Understand and use the angle properties of parallel lines, intersecting lines, triangles and quadrilaterals.
Calculate and use the sum of the interior angles, and the sum of the exterior angles, of polygons.
- M5.3 Derive and apply the properties and definitions of special types of quadrilaterals, including square, rectangle, parallelogram, trapezium, kite and rhombus.
Derive and apply the properties and definitions of various types of triangle and other plane figures using appropriate language.
- M5.4 Understand and use the basic congruence criteria for triangles (SSS, SAS, ASA, RHS).
- M5.5 Apply angle facts, triangle congruence, similarity, and properties of quadrilaterals to results about angles and sides.
- M5.6 Identify, describe and construct congruent and similar shapes, including on coordinate axes, by considering rotation, reflection, translation and enlargement (including fractional and negative scale factors).
Describe the changes and invariance achieved by combinations of rotations, reflections and translations.
Describe translations as 2-dimensional vectors.
- M5.7 Know and use the formula for Pythagoras' theorem: $a^2 + b^2 = c^2$
Use Pythagoras' theorem in both 2 and 3 dimensions.
- M5.8 Identify and use conventional circle terms: *centre*, *radius*, *chord*, *diameter*, *circumference*, *tangent*, *arc*, *sector* and *segment* (including the use of the terms *minor* and *major* for arcs, sectors and segments).
- M5.9 Apply the standard circle theorems concerning angles, radii, tangents and chords, and use them to prove related results:
- angle subtended at the centre is twice the angle subtended at the circumference
 - angle in a semicircle is 90°
 - angles in the same segment are equal
 - angle between a tangent and a chord (alternate segment theorem)
 - angle between a radius and a tangent is 90°
 - properties of cyclic quadrilaterals
- M5.10 Solve geometrical problems on 2-dimensional coordinate axes.
- M5.11 Know the terminology *faces*, *surfaces*, *edges* and *vertices* when applied to cubes, cuboids, prisms, cylinders, pyramids, cones, spheres and hemispheres.

M5.12 Interpret plans and elevations of 3-dimensional shapes.

M5.13 Use and interpret maps and scale drawings.

Understand and use three-figure bearings.

M5.14 Know and apply formulae to calculate:

a. the area of triangles, parallelograms, trapezia

b. the volume of cuboids and other right prisms.

M5.15 Know the formulae:

a. circumference of a circle = $2\pi r = \pi d$

b. area of a circle = πr^2

c. volume of a right circular cylinder = $\pi r^2 h$

Formulae relating to spheres, pyramids and cones will be given if needed.

Use formulae to calculate:

a. perimeters of 2-dimensional shapes, including circles

b. areas of circles and composite shapes

c. surface area and volume of spheres, pyramids, cones and composite solids

M5.16 Calculate arc lengths, angles and areas of sectors of circles.

M5.17 Apply the concepts of congruence and similarity in simple figures, including the relationships between lengths, areas and volumes.

M5.18 Know and use the trigonometric ratios:

$$\sin \theta = \frac{\text{opposite}}{\text{hypotenuse}} \quad \cos \theta = \frac{\text{adjacent}}{\text{hypotenuse}} \quad \tan \theta = \frac{\text{opposite}}{\text{adjacent}}$$

Apply these to find angles and lengths in right-angled triangles and, where possible, general triangles in 2- and 3-dimensional figures.

Know the exact values of $\sin \theta$ and $\cos \theta$ for $\theta = 0^\circ, 30^\circ, 45^\circ, 60^\circ, 90^\circ$.

Know the exact values of $\tan \theta$ for $\theta = 0^\circ, 30^\circ, 45^\circ, 60^\circ$.

Candidates are not expected to recall or use the sine or cosine rules.

M5.19 Apply addition and subtraction of vectors, multiplication of vectors by a scalar, and diagrammatic and column representations of vectors.

Use vectors to construct geometric arguments and proofs.

M6. Statistics

- M6.1 Interpret and construct tables, charts and diagrams, including:
- two-way tables, frequency tables, bar charts, pie charts and pictograms for categorical data
 - vertical line charts for ungrouped discrete numerical data
 - tables and line graphs for time series data

Know the appropriate use of each of these representations.

- M6.2 Interpret and construct diagrams for grouped discrete data and continuous data:
- histograms with equal and unequal class intervals
 - cumulative frequency graphs

Know the appropriate use of each of these diagrams.

Understand and use the term *frequency density*.

- M6.3 Calculate the *mean, mode, median and range* for ungrouped data.
Find the modal class; calculate estimates of the range, mean and median for grouped data, and understand why these are estimates.
Describe a population using statistics.
Make simple comparisons.
Compare data sets using like-for-like summary values.
Understand the advantages and disadvantages of summary values.
Calculate estimates of mean, median, mode, range, quartiles and interquartile range from graphical representation of grouped data.
Use the median and interquartile range to compare distributions.
- M6.4 Use and interpret scatter graphs of bivariate data.
Recognise correlation, and know that it does not indicate causation.
Draw estimated lines of best fit.
Interpolate and extrapolate apparent trends whilst knowing the dangers of so doing.

M7. Probability

- M7.1 Analyse the frequency of outcomes of probability experiments using tables and frequency trees.
- M7.2 Apply ideas of randomness, fairness and equally likely events to calculate expected outcomes of multiple future experiments.
Understand that if an experiment is repeated, the outcome may be different.
- M7.3 Relate relative expected frequencies to theoretical probability, using appropriate language and the '0 to 1' probability scale.

- M7.4 Apply the property that the probabilities of an exhaustive set of outcomes sum to one.
Apply the property that the probabilities of an exhaustive set of mutually exclusive events sum to one.
- M7.5 Enumerate sets and combinations of sets systematically, using tables, grids, Venn diagrams and tree diagrams. Candidates are not expected to know formal set theory notation.
- M7.6 Construct theoretical possibility spaces for single and combined experiments with equally likely outcomes, and use these to calculate theoretical probabilities.
- M7.7 Know when to add or multiply two probabilities, and understand conditional probability.
Calculate and interpret conditional probabilities through representation using expected frequencies with two-way tables, tree diagrams and Venn diagrams.
Understand the use of tree diagrams to represent outcomes of combined events:
- a. when the probabilities are independent of the previous outcome
 - b. when the probabilities are dependent on the previous outcome.

ADVANCED MATHEMATICS

AM1. Algebra and functions

AM1.1 Laws of indices for all rational exponents.

AM1.2 Use and manipulation of surds.

Simplifying expressions that contain surds, including rationalising the denominator.

For example: simplifying $\frac{\sqrt{5}}{3+2\sqrt{5}}$ and $\frac{3}{\sqrt{7}-2\sqrt{3}}$

AM1.3 Quadratic functions and their graphs; the discriminant of a quadratic function; completing the square; solution of quadratic equations.

AM1.4 Simultaneous equations: analytical solution by substitution, e.g. of one linear and one quadratic equation.

AM1.5 Solution of linear and quadratic inequalities.

AM1.6 Algebraic manipulation of polynomials, including:

a. expanding brackets and collecting like terms

b. factorisation and simple algebraic division (by a linear polynomial, including those of the form $ax + b$, and by quadratics, including those of the form $ax^2 + bx + c$)

c. use of the Factor Theorem and the Remainder Theorem

AM1.7 Qualitative understanding that a function is a many-to-one (or sometimes just a one-to-one) mapping.

Familiarity with the properties of common functions, including $f(x) = \sqrt{x}$ (which always means the 'positive square root') and $f(x) = |x|$.

AM2. Sequences and series

AM2.1 Sequences, including those given by a formula for the n^{th} term and those generated by a simple recurrence relation of the form $x_{n+1} = f(x_n)$

AM2.2 Arithmetic series, including the formula for the sum of the first n natural numbers.

AM2.3 The sum of a finite geometric series.

The sum to infinity of a convergent geometric series, including the use of $|r| < 1$

AM2.4 Binomial expansion of $(1 + x)^n$ for positive integer n , and for expressions of the form $(a + f(x))^n$ for positive integer n and simple $f(x)$.

The notations $n!$ and $\binom{n}{r}$.

AM3. Coordinate geometry in the (x,y) -plane

AM3.1 Equation of a straight line, including:

a. $y - y_1 = m(x - x_1)$

b. $ax + by + c = 0$

Conditions for two straight lines to be parallel or perpendicular to each other.

Finding equations of straight lines given information in various forms.

AM3.2 Coordinate geometry of the circle, using the equation of a circle in the forms:

a. $(x - a)^2 + (y - b)^2 = r^2$

b. $x^2 + y^2 + cx + dy + e = 0$

AM3.3 Use of the following circle properties:

a. The perpendicular from the centre to a chord bisects the chord.

b. The tangent at any point on a circle is perpendicular to the radius at that point.

c. The angle subtended by an arc at the centre of a circle is twice the angle subtended by the arc at any point on the circumference.

d. The angle in a semicircle is a right angle.

e. Angles in the same segment are equal.

f. The opposite angles in a cyclic quadrilateral add to 180° .

g. The angle between the tangent and chord at the point of contact is equal to the angle in the alternate segment.

AM4. Trigonometry

AM4.1 The sine and cosine rules, and the area of a triangle in the form $\frac{1}{2}ab \sin C$.

The sine rule includes an understanding of the 'ambiguous' case (angle-side-side).

Problems might be set in 2 or 3 dimensions.

AM4.2 Radian measure, including use for arc length and area of sector and segment.

AM4.3 The values of sine, cosine and tangent for the angles: 0° , 30° , 45° , 60° , 90° .

AM4.4 The sine, cosine and tangent functions; their graphs, symmetries, and periodicity.

AM4.5 Knowledge and use of the equations:

a. $\tan \theta = \frac{\sin \theta}{\cos \theta}$

b. $\sin^2 \theta + \cos^2 \theta = 1$

AM4.6 Solution of simple trigonometric equations in a given interval (this may involve the use of the identities in 4.5).

For example: $\tan \theta = -\frac{1}{\sqrt{3}}$ for $-\pi < x < \pi$ $\sin^2(2x + \frac{\pi}{3}) = \frac{1}{2}$ for $-2\pi < x < 2\pi$

$$12\cos^2 x + 6\sin x - 10 = 2 \text{ for } 0^\circ < x < 360^\circ$$

AM5. Exponentials and logarithms

AM5.1 $y = a^x$ and its graph, for simple positive values of a .

AM5.2 Laws of logarithms:

- a. $a^b = c \Leftrightarrow b = \log_a c$
- b. $\log_a x + \log_a y = \log_a (xy)$
- c. $\log_a x - \log_a y = \log_a \left(\frac{x}{y} \right)$
- d. $k \log_a x = \log_a (x^k)$

including the special cases:

- e. $\log_a \left(\frac{1}{x} \right) = -\log_a x$
- f. $\log_a a = 1$

Questions requiring knowledge of the change of base formula will not be set.

AM5.3 The solution of equations of the form $a^x = b$, and equations which can be reduced to this form, including those that need prior algebraic manipulation.

For example: $3^{2x} = 4$ and $25^x - 3 \times 5^x + 2 = 0$

AM6. Differentiation

AM6.1 The derivative of $f(x)$ as the gradient of the tangent to the graph $y = f(x)$ at a point.

- a. Interpretation of a derivative as a rate of change.
- b. Second-order derivatives.
- c. Knowledge of notation: $\frac{dy}{dx}$, $\frac{d^2y}{dx^2}$, $f'(x)$, and $f''(x)$

Differentiation from first principles is excluded.

AM6.2 Differentiation of x^n for rational n , and related sums and differences. This might require some simplification before differentiating.

For example, the ability to differentiate an expression such as $\frac{(3x+2)^2}{x^{\frac{1}{2}}}$

AM6.3 Applications of differentiation to gradients, tangents, normals, stationary points (maxima and minima only), increasing functions [$f'(x) \geq 0$] and decreasing functions [$f'(x) \leq 0$]. Points of inflexion will not be examined, although a qualitative understanding of points of inflexion in the curves of simple polynomial functions is expected.

AM7. Integration

AM7.1 Definite integration as related to the 'area between a curve and an axis'. The difference between finding a definite integral and finding the area between a curve and an axis is expected to be understood.

AM7.2 Finding definite and indefinite integrals of x^n for n rational, $n \neq 1$, and related sums and differences, including expressions which require simplification prior to integrating.

$$\text{For example: } \int (x+2)^2 dx \quad \text{and} \quad \int \frac{(3x-5)^2}{x^{\frac{1}{2}}} dx$$

AM7.3 An understanding of the Fundamental Theorem of Calculus and its significance to integration. Simple examples of its use may be required in the forms:

a. $\int_a^b f(x) dx = F(b) - F(a)$, where $F'(x) = f(x)$

b. $\frac{d}{dx} \int_a^x f(x) dx = f(x)$

AM7.4 Combining integrals with either equal or contiguous ranges.

$$\text{For example: } \int_2^5 f(x) dx + \int_2^5 g(x) dx = \int_2^5 [f(x) + g(x)] dx$$

$$\int_2^4 f(x) dx + \int_4^3 f(x) dx = \int_2^3 f(x) dx$$

AM7.5 Approximation of the area under a curve using the trapezium rule; determination of whether this constitutes an overestimate or an underestimate.

AM7.6 Solving differential equations of the form $\frac{dy}{dx} = f(x)$

AM8. Graphs of functions

AM8.1 Recognise and be able to sketch the graphs of common functions that appear in this specification: these include lines, quadratics, cubics, trigonometric functions, logarithmic functions, exponential functions, square roots, and the modulus function.

AM8.2 Knowledge of the effect of simple transformations on the graph of $y = f(x)$ with positive or negative value of a as represented by:

a. $y = af(x)$

b. $y = f(x) + a$

c. $y = f(x + a)$

d. $y = f(ax)$

Compositions of these transformations.

AM8.3 Understand how altering the values of m and c affects the graph of $y = mx + c$

AM8.4 Understand how altering the values of a , b and c in $y = a(x + b)^2 + c$ affects the corresponding graph.

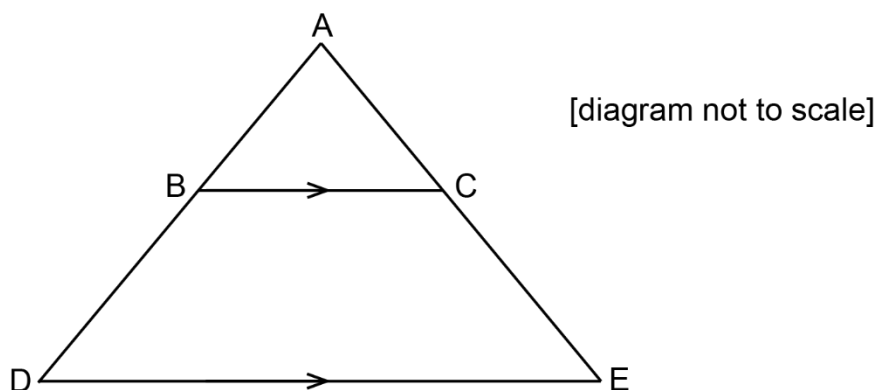
- AM8.5 Use differentiation to help determine the shape of the graph of a given function, including:
- a. finding stationary points (excluding inflexions)
 - b. when the graph is increasing or decreasing
- AM8.6 Use algebraic techniques to determine where the graph of a function intersects the coordinate axes; appreciate the possible numbers of real roots that a general polynomial can possess.
- AM8.7 Geometric interpretation of algebraic solutions of equations; relationship between the intersections of two graphs and the solutions of the corresponding simultaneous equations.

APPENDIX 2: EXAMPLE QUESTIONS

In the following multiple-choice questions, the correct answer has been underlined.

Section 1, Part A: Mathematics

A shape is formed by drawing a triangle ABC inside the triangle ADE .



BC is parallel to DE .

$$AB = 4 \text{ cm} \quad BC = x \text{ cm} \quad DE = (x + 3) \text{ cm} \quad DB = (x - 4) \text{ cm}$$

What is the length, in cm, of DE ?

- A 5
- B 7
- C 9
- D $4 + 2\sqrt{7}$
- E $7 + 2\sqrt{7}$

Section 1, Part B: Advanced Mathematics

What is the smallest possible value of $\int_0^1 (x-a)^2 dx$ as a varies?

A $\frac{1}{12}$

B $\frac{1}{3}$

C $\frac{1}{2}$

D $\frac{7}{12}$

E 2

Section 2: Essay question and text

Read the article 'Should America want a strong dollar? It's complicated' taken from *The Economist* (February 9th 2017). Based on this text, complete the task below.

TASK

- Explain why in some circumstances a rise in the value of the US dollar might benefit American residents, while in other circumstances it would be harmful to them.
- Suggest possible reasons why the US dollar might be persistently overvalued.

Your answer will be assessed taking into account your ability to construct a reasoned, insightful and logically consistent argument with clarity and precision.

Should America want a strong dollar? It's complicated

In an experience we have all had, Donald Trump, unable to sleep, reportedly rang his National Security Advisor at 3:00 in the morning to ask whether America should want a strong dollar or a weak one. Look, there are no stupid questions. This one is actually more interesting than you might think. There are a few ways to answer it.

One way is to ask what it would mean if there were a random rise in the dollar (caused, say, by noise trading). Tyler Cowen takes this approach. Since most Americans have their incomes and wealth in dollars, a rise in the dollar would generally be good for America and bad for non-Americans: with caveats, including the fact that a stronger dollar might cause financial trouble for indebted emerging markets which could feed back into the American economy.

That's fine and all, but the dollar usually does what it does for a reason, or some set of reasons, and the answer to the question depends on *why* the dollar is strong or weak. Matt Yglesias gives his answer using this approach. If the dollar is rising because the Fed is inducing a deflationary recession, that's probably not good for anyone. (This is not outside the realm of plausibility, as it happens; Britain suffered years of painful deflation in the 1920s in order to defend sterling's peg to gold at an overvalued rate, only to then subsequently devalue during the Depression.) If the dollar is rising because America has discovered something amazing (like oil, or plutons) and the world cannot get enough of it, then that's probably good for everyone – though it is worth remembering that in all of these cases there are winners and losers, in America and elsewhere.

But another way to approach the question is to ask whether the dollar is overvalued or undervalued. If the dollar is overvalued, then a bout of weakening would be a healthy thing. How can you tell if a currency is overvalued or undervalued? Well, you can consult your nearest Big Mac index. Alternatively, you can check the current-account balance. If a country is persistently running current-account surpluses, its currency is probably undervalued; deficits, overvalued. America has been running current-account deficits since the early 1980s, therefore its currency is overvalued and a weaker dollar would be better.

Ok, but hold on. How is it that the dollar hasn't adjusted to its appropriate value after nearly 40 years. That, it turns out, is the critical question.

The dollar has been overvalued all this time because the dollar is a reserve currency. Not just a reserve currency, but rather the world's dominant reserve currency, by a long shot. It holds that position partly for reasons of path dependence: because the dollar was the anchor currency in the postwar Bretton Woods agreement, other economies accumulated lots of dollar reserves to help maintain their fixed exchange rate. It holds the position partly because of network externalities; if lots of people do their trade invoicing in dollars, it is convenient for you to also do your business stuff in dollars to keep everything simple. And it holds that position in large part because no other currency, or country, is as capable of providing reserve-currency services. America has a very large and rich and stable economy, a high tax-revenue generating capacity, an extremely credible central bank, a stable democracy (knock wood), massive military and diplomatic power, broad and deep financial markets, and so on. The point is: America can provide large amounts of dollars, and government bonds, and other dollar-denominated assets without getting anywhere near the sorts of crises that might lead to sudden or unexpected changes in value in those dollars and bonds and such. Just as important, America has historically accepted the role of reserve-currency provider and the responsibilities that entails: like cooperating with other countries in crises to provide emergency dollar liquidity. America is the total package, or has been anyway.

What that has tended to mean, then, is that foreign firms and governments buy American government bonds by the truckload. Foreign appetite for dollars and dollar assets – even the super boring low-yield ones – allows Americans to buy more than they produce. It seems like a win-win situation. The dollar-as-a-reserve currency is a public good of sorts, a lubricant for global trade and finance, provided by America to the rest of the world. In return, Americans get to buy more than they make, forever. As explained elsewhere in this issue of the Economist, there are downsides, though:

“An overvalued currency and persistent trade deficits are fine for America’s consumers, but painful for its producers. The reserve accumulation of the past two decades has gone hand-in-hand with a soaring current-account deficit in America. Imports have grown faster than exports; new jobs in exporting industries have not appeared in numbers great enough to absorb workers displaced by increased foreign competition. Tariffs cannot fix this problem. The current-account gap is a product of underlying financial flows, and taxing imports will simply cause the dollar to rise in an offsetting fashion.

America’s privilege also increases inequality, since lost jobs in factories hurt workers while outsize investment performance benefits richer Americans with big portfolios. Because the rich are less inclined to spend an extra dollar than the typical worker, this shift in resources creates weakness in American demand – and sluggish economic growth – except when consumer debt rises as the rich lend their purchasing power to the rest.

Chalk the headaches generated by low interest rates up to the dollar standard, too. Some economists reckon they reflect global appetite outstripping the supply of the safe assets America is uniquely equipped to provide – dollar-denominated government bonds. As the price of safe bonds rises, rates on those bonds fall close to zero, leaving central banks with ever less room to stimulate their economies when they run into trouble.”

So one could ask whether a strong dollar is better or a weak one. But one could also ask whether it is in America's long-term interest to continue supporting the global dollar standard. In my view, it is neither sustainable or desirable for America to continue to play this role on its own. On the other hand, the status quo is preferable to the chaotic destruction of the dollar standard in the absence of a ready replacement. Put in the shoes of Mike Flynn, Mr Trump's National Security Advisor, I'm not sure quite how I'd respond. But the answer would start with, 'First, Mr President, give me your phone'.

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