Year 12 Applied

Modelling in Mechanics - Definitions

Objectives. Students are expected to learn:

- Understand and use fundamental quantities and units in the SI system: length, time, mass
- Understand and use derived quantities and units: velocity, acceleration, force, weight.
- Know the difference between position, displacement and distance;
- Know the difference between velocity and speed and between acceleration and magnitude of acceleration
- Know the difference between mass and weight (including gravity)
- Understand there are different types of forces.
- Understand the concept of a mathematical model

Suggested time scale: 4 - 5 lessons

Misconceptions

Students may mix up mass and weight and their related units. Some struggle to use the correct vocabulary e.g. for velocity and displacement. It is important to be really clear when giving the definitions and to always use the correct vocabulary in discussions.

Students can generally correctly state assumptions, but they need to make sure that any assumptions or statements about the model relate directly to the context they are considering. For example, they could make the comment 'the resistance will not be constant' more specific by saying 'resistance will increase as velocity increases'.

Key Words Tier 2

Assumptions, modelling, smooth, rough, light, direction, reaction, tension, plane.

Key Words Tier 3

Inelastic, inextensible, particle, rigid body, mass, weight, rod, lamina, length, distance (m), displacement (m), velocity (m s^{-1}), speed (m s^{-1}), acceleration (m s^{-2}), force (N), retardation (m s^{-2}), newtons (N), scalar, vector, direction, magnitude, (normal), friction, thrust, compression

Homework

Book 1 Mixed exercise Unit 8

Careers links

Mechanical engineering

Employability skills

Aiming high	Literacy	Creativity	Numeracy
Leadership	Independence	Listening	Communication
Presenting	Teamwork	Problem solving	Staying positive
Critical thinking	Analytical thinking	Time management	

Enrichment

1) Senior Maths Challenge on 1st October 2024

We are regular participants in the maths challenge competition, and students speak highly of the chance to solve mathematical puzzles. This reinforces the foundations of mathematics as a problem-solving activity, and develops the skills required later by university admissions departments.

2) Free online Transition to University Course – Advanced Mathematics support programme Transition to University Course

The Transition to University Course 2024 course is designed for students who are:
Currently in Year 13 or taking a gap year.
Studying A level Mathematics.
Planning to begin studying a degree in maths, engineering, sciences, or closely related subjects such as economics in 2024 (or choosing to defer their entry until 2025).

Assessment: Quantities and Units in Mechanics

Kinematics 1 (Constant acceleration)

Objectives. Students are expected to learn:

- Understand and use the language of kinematics: position; displacement; distance travelled; velocity; speed; acceleration.
- Understand, use and interpret graphs in kinematics for motion in a straight line: displacement against time and interpretation of gradient; velocity against time and interpretation of gradient and area under the graph.
- Be able to draw and interpret kinematics graphs, knowing the significance (where appropriate) of their gradients and the areas underneath them.
- Understand, use and derive formulae for constant acceleration for motion in a straight line (SUVAT equations).
- Recognise when it is appropriate to use the suvat formulae for constant acceleration.
- Be able to solve kinematics problems using constant acceleration formulae.
- Be able to solve problems involving vertical motion under gravity.
- Understand and use weight and motion in a straight line under gravity; gravitational acceleration, g,
- and its value in S.I. units to varying degrees of accuracy.

Suggested time scale: 5 - 6 lessons

Misconceptions

Many students can draw a velocity time graph with the correct shape, but do not always label the required speeds and times clearly on the axes. Students often tend to add a scale (for example 4, 8, 12, 16, …) unnecessarily, rather than just indicating the initial and final speeds.

Candidates are able to find distance travelled and the acceleration from velocity–time graphs and can find an average speed, but some struggle with the vocabulary of velocity and displacement.

Students are generally able to use suvat formulae in 2D to find unknown heights, velocities etc. However, students sometimes ignore the significance of a negative value for velocity, acceleration or displacement and don't refer their answer back to the original problem. They need to recognise that s = –3 m means the object is 3 m below its starting point in the negative direction i.e. s is effectively a coordinate. This is where a diagram helps students understand the physics of the situation.

Key Words Tier 2

Graph, average, represent, model, derive.

Key Words Tier 3

Distance (m), displacement (m), speed (m s^{-1}), velocity (m s^{-1}), acceleration (m s^{-2}), retardation (m s^{-2}), deceleration (m s^{-2}), scalar, vector, 2D, linear, area, trapezium, gradient, equations of motion, gravity, constant, 9.8 m s^{-2}, vertical.

Homework

Book 1 Mixed exercise Unit 9

Mathsgenie website: SUVAT, Velocity Time Graphs, Variable Acceleration

Careers links

AI Development Analyst

Employability skills

Aiming high	Literacy	Creativity	Numeracy
Leadership	Independence	Listening	Communication
Presenting	Teamwork	Problem solving	Staying positive
Critical thinking	Analytical thinking	Time management	

Assessment: Kinematics 1 (constant acceleration)

Data Collection – Statistical sampling

Objectives. Students are expected to learn:

- Introduction to sampling terminology:
- Understand and be able to use the terms ‘population’ and ’sample’.
- Know how to use samples to make informal inferences about the population.
- Be able to describe the advantages and disadvantages of sampling compared to census.
- Understand and be able to use sampling techniques:
- Able to select or critique sampling techniques in the context of solving a statistical problem.
- Understand that different samples can lead to different conclusions about the population.
- Understand and be able to identify different types of data.
- Know and be able to use the large data set.

Suggested time scale: 6 -7 lessons

Misconceptions

Some students confuse sample sizes and population sizes, but the recurring problem is not giving answers in context. Candidates need to be clear about the difference between sample sizes and population sizes.
Students need to be able to describe the sampling techniques clearly and will lose marks if they are not sufficiently precise.
As always, answers must be given using the context of the question and not simply be quoted from text books in a general form.

Key Words Tier 2

Population, census, sample.

Key Words Tier

Sampling unit, sampling frame, simple random sampling, stratified, systematic, quota, opportunity (convenience) sampling.

Homework

Book 1 Mixed exercise Unit 9
Mathsgenie website: Sampling

Careers links

Astronomer

Employability skills

Aiming high	Literacy	Creativity	Numeracy
Leadership	Independence	Listening	Communication
Presenting	Teamwork	Problem solving	Staying positive
Critical thinking	Analytical thinking	Time management	

Assessment: Statistical Sampling

Measures of Location and Spread

Objectives. Students are expected to learn:

- Calculation and interpretation of measures of location:
  - be able to calculate measures of location, mean, median and mode, as well as quartiles and percentiles
  - be able to calculate measures of variation, standard deviation, variance, range and interpercentile range using linear interpolation; percentiles from grouped data using linear interpolation
- -be able to calculate standard deviation from summary statistics
  - be able to interpret and draw inferences from summary statistics
  - data may be discrete, continuous, grouped or ungrouped
- Coding for both mean and standard deviation - must be able to uncode both mean and standard deviation

Suggested time scale: 5 - 6 lessons

Misconceptions

When calculating the mean, of grouped data some student may divide by the number of groups rather than the number of items of data, they may also use class widths in the calculation rather than the mid-points.

When finding the standard deviation, the most common error is forgetting to take the square root (perhaps because they are not clear about the difference between variance and standard deviation). Some students waste time by ignoring given values and recalculating Σfx and Σfx2.

Difficulties with coding are due to a lack of understanding about how coding affects the mean and standard deviation, and poor algebraic skills. Students sometimes substitute for the wrong variable, fail to solve equations correctly or get the order of operations the wrong way around.

Students should be reminded that they must be precise in their use of language and use the correct terms such as ‘median’. ‘range’ or ‘inter-quartile range’ rather than the more general ‘average’ and ‘spread’. Students should also remember to use accurate values throughout calculations to avoid losing marks due to premature rounding.

Key Words Tier 2

Frequency, range, code, data set.

Key Words Tier 3

Mean, median, mode, variance, standard deviation, interquartile range, interpercentile range, outlier, skewness, symmetrical, positive skew, negative skew.

Homework

Book 1 Mixed exercise Unit 2

Mathsgenie website: Interpolation and Standard Deviation

Career links

Chartered Accountant

Employability skills

Aiming high	Literacy	Creativity	Numeracy
Leadership	Independence	Listening	Communication
Presenting	Teamwork	Problem solving	Staying positive
Critical thinking	Analytical thinking	Time management	

Representations of Data

Objectives. Students are expected to learn:

- Be able to clean data, including dealing with missing data, errors and outliers.
- Be able to represent data in the forms of histograms, frequency polygons, box and whisker plots and
- cumulative frequency diagrams.
- Know how to interpret diagrams (histograms, frequency polygons, box and whisker plots and cumulative frequency diagrams) for single variable data
- Be able to select or critique data presentation techniques in the context of a statistical problem.
- Be able to compare data sets and comment on them.

Suggested time scale: 5 - 6 lessons

Misconceptions

Many students have difficulties calculating the sizes of bars in histograms, as commented on by one examiner: 'Most were able to state the correct width of the bar but few used frequency densities correctly to find the height, some finding the frequency density ofbut then calculating $\frac{1}{3} \times 2.5$ rather than $2.5 \div \frac{1}{3}$. Some identified that 1.5 cm2represented 10 customers but were then unable to use this correctly to find the height … some students had an incorrect class width because they did not realize that the lower class boundary was 70 not 69.5.'

Key Words Tier 2

Represent, frequency, measure, process, anomaly.

Key Words Tier 3

Histogram, box plot, probability density function, cumulative distribution function, continuous random variable, scatter diagram

Homework

Book 1 Mixed exercise Unit 3

Mathsgenie website: Histograms, Box Plots

Career links

Real Estate Investment Analyst

Employability skills

Aiming high	Literacy	Creativity	Numeracy
Leadership	Independence	Listening	Communication
Presenting	Teamwork	Problem solving	Staying positive
Critical thinking	Analytical thinking	Time management	

Assessment:

Data presentation and interpretation

Forces and Motion

Objectives. Students are expected to learn:

- Understand the concept of a force; understand and use Newton's first law.
- Be able to draw force diagrams.
- Be able to find the resultant vector of two or more forces.
- Understand and use Newton's second law (***F = ma***) for motion in a straight line (restricted to forces in two perpendicular direction or simple cases of forces given as 2D (i, j) vectors); extend to situations where forces need to be resolved (restricted to 2 dimensions).
- Understand and use Newton's third law; equilibrium of forces on a particle and motion in a straight line; application to problems involving smooth pulleys and connected particle including problems with particles in contact e.g. lift problems.
- (no resolving forces or use of F = μR)

Suggested time scale: 7 - 8 lessons

Misconceptions

Students are often good at drawing force diagrams, but common errors are omitting arrowheads, incorrectly labelling (e.g. 4 kg rather than 4g) and missing off the normal reaction. Students can easily be confused by the vocabulary, e.g. mixing up 'resultant' and 'reaction'.

Pulleys: In past exam questions, most students used an equation of motion for each particle with very few 'single equation' solutions. Students may also mistakenly take the acceleration to be equal to g rather than the value obtained in the question.

2 Vehicles: In exam questions of a car-and-trailer type, students may consider the car and trailer as a single system. Common errors when resolving are: to add a tension force (when there is no rope): to consider the weight; or to confuse the positive and negative directions.

Key Words Tier 2

Negligible, smooth, rough, tension, object.

Key Words Tier 3

Force, newtons, mass, weight, gravity, thrust, compression, air resistance, reaction, driving force, braking force, resultant, force diagram, equilibrium, inextensible, light, particle, uniform, pulley, string, retardation, free particle.

Homework

Book 1 Mixed exercise Unit 10

Mathsgenie website: 2D Vectors, F = ma

Career links

Manufacturing engineer

Employability skills

Aiming high	Literacy	Creativity	Numeracy
Leadership	Independence	Listening	Communication
Presenting	Teamwork	Problem solving	Staying positive
Critical thinking	Analytical thinking	Time management	

Assessment:

Forces and Newton's Laws

Correlation

Objectives. Students are expected to learn:

- Know how to interpret scatter diagrams and regression lines for bivariate data.
- Recognise explanatory and response variables.
- Be able to make predictions using the regression line and understand its limitations.
- Understand informal interpretation of correlation.
- Understand correlation does not imply causation.
- Recognise and interpret possible outliers in data sets and statistical diagrams.

Suggested time scale: 2 - 3 lessons

Misconceptions

Students often fail to remember that the order of variables is important. The regression line of y on x will be different from the regression line of x on y.
Students sometimes confuse interpolation and extrapolation. Another typical mistake is to make predictions for the independent variable rather than the dependent one.
Correlation can only be used to describe data that shows linear relationship.

Key Words Tier 2

Plot, describe, interpret, determine.

Key Words Tier 3

Scatter diagram, bivariate data, linear regression, explanatory (independent) variables, response (dependent) variables interpolation, extrapolation, product moment correlation coefficient (PMCC).

Homework

Book 1 Mixed exercise Unit 4
Mathsgenie website: Correlation and Regression

Career links

Oil and gas engineering

Employability skills

Aiming high	Literacy	Creativity	Numeracy
Leadership	Independence	Listening	Communication
Presenting	Teamwork	Problem solving	Staying positive
Critical thinking	Analytical thinking	Time management	

Probability
Objectives. Students are expected to learn: • Be able to use terminology related to probability (e.g. outcomes, experiment, event, sample space, etc.). • Be able to use tree diagrams, Venn diagrams and two-way tables. • Understand and be able to use mutually exclusive **P(A or B) = P(A) + P(B)** and independent events **P(A and B) = P(A) x P(B)** when calculating probabilities. • Be able to make links with discrete and continuous distributions. • Understand and be able to use probability formulae using set notation. Suggested time scale: 4 - 5 lessons
Misconceptions Sample space, exclusive event, complementary event, discrete random variable, continuous random variable, mathematical modelling, independent, mutually exclusive, Venn diagram, tree diagram. Students may confuse 'independent' and 'mutually exclusive'. Using a diagram almost always helps students to answer probability questions. When drawing a Venn diagram, students should remember to include a box defining the universal set.
Key Words Tier 2 Frequency, region, outcome, modelling.
Key Words Tier 3 Sample space, exclusive event, complementary event, discrete random variable, continuous random variable, mathematical modelling, independent, mutually exclusive, Venn diagram, tree diagram.
Homework Book 1 Mixed exercise Unit 5 Mathsgenie website: Probability
Career links Telecommunication engineer
Employability skills Aiming high — Literacy — Creativity — Numeracy Leadership — Independence — Listening — Communication Presenting — Teamwork — Problem solving — Staying positive Critical thinking — Analytical thinking — Time management
Assessment: **Probability**

Statistical Distributions

Objectives. Students are expected to learn:

- Understand and use simple, discrete probability distributions.
- Understand discrete uniform distribution.
- Understand and know the binomial distribution as a model and its criteria.
- Calculate probabilities, including cumulative probabilities, using the binomial distribution.
- Understand the meaning of a probability mass functions.
- Be able to use your calculator to find the individual or cumulative binomial probabilities.

Suggested time scale: 3 - 4 lessons

Misconceptions

The most common difficulty is with manipulating inequalities: 'A significant number of students were unable to cope with the expression $\mathrm{P}(5 \leq X < 11)$. There were students who translated this expression into the more convenient form $\mathrm{P}(5 \leq X \leq 10)$ and then in turn transformed this into an equivalent form that can be applied to the table of cumulative probabilities: $\mathrm{P}(X \leq 10) - \mathrm{P}(X \leq 4)$. However, there were also many instances of incorrect versions such as: $\mathrm{P}(X < 11) - \mathrm{P}(X \geq 5)$, $\mathrm{P}(X \leq 10) + \mathrm{P}(X \geq 5)$, $\mathrm{P}(X \leq 10) - (1 - \mathrm{P}(X \geq 5))$ and P(X ≤ 11) – either P(X ≤ 5) or P(X ≤ 4).'

In a similar vein, students have a tendency to write, for example, P(X> 2) as 1 – P(X ≤ 1) instead of 1 – P(X ≤ 2).

Key Words Tier 2

Outcome, model, distribution, independent.

Key Words Tier 3

Binomial, probability, discrete distribution, discrete random variable, uniform, cumulative probabilities.

Homewor

Book 1 Mixed exercise Unit 6

Mathsgenie website: Discrete Random Variables

Career links

Patent examiner, Data scientist

Employability skills

Aiming high	Literacy	Creativity	Numeracy
Leadership	Independence	Listening	Communication
Presenting	Teamwork	Problem solving	Staying positive
Critical thinking	Analytical thinking	Time management	

Assessment:

Statistical Distributions

Hypothesis testing

Objectives. Students are expected to learn:

- Understand the language and concept of Hypothesis Testing developed through a binomial model.
- Understand and be able to write null hypothesis; alternative hypothesis and find significance levels.
- Be able to find critical values of a binomial distribution using tables.
- Be able to carry out one-tailed tests and two-tailed tests, find the critical region, acceptance region; p-value.
- Carry out hypothesis testing using the binomial distribution and interpret the results in context.
- Understand that a sample is being used to make an inference about the population and appreciate the significance level is the probability of incorrectly rejecting the null hypothesis.

Suggested time scale: 3 - 4 lessons

Misconceptions

Emphasise the importance of stating hypotheses clearly using the correct notation.

Similarly, correct notation is important when describing the critical region: 'There were still a few students using incorrect notation for critical regions: P($X \leq 1$), for example, is not a critical region: it is a probability.'

The most common error in these sorts of questions include not writing a clear conclusion in the context of the question. Students either omit the context or sometimes fail to give any conclusion to their calculations.

Key Words Tier 2

Hypotheses, alternative, assume, reject, critical, associated, compare.

Key Words Tier 3

Significance level, one-tailed test, two-tailed test, test statistic, null hypothesis, alternative hypothesis, critical value, critical region, acceptance region, p-value, binomial model, accept, reject, sample, inference.

Homework

Book 1 Mixed exercise Unit 7

Mathsgenie website: Binomial Hypothesis Testing

Career links

Management consultancy

Employability skills

Aiming high	Literacy	Creativity	Numeracy
Leadership	Independence	Listening	Communication
Presenting	Teamwork	Problem solving	Staying positive
Critical thinking	Analytical thinking	Time management	

Assessment:

Statistical Hypothesis Testing

Variable acceleration

Objectives. Students are expected to learn:

- Understand that displacement, velocity and acceleration may be given as functions of time.
- Use calculus (differentiation) in kinematics to model in a straight line for particle moving with variable acceleration

$$v = \frac{ds}{dt} \text{ and } v = \frac{dv}{dt} = \frac{d^2v}{dt^2}.$$

- Understand that gradients of the relevant graphs link to rates of change.
- Know how to find max and min velocities by considering zero gradient and understand how this links to actual motion (ie acceleration=0).
- Use calculus (integration) in kinematics to model motion in a straight line for a particle moving under the action of a variable force.

$$s = \int v\, dt \text{ and } v = \int a\, dt.$$

- Understand area under a graph is the integral, which leads to a physical quantity.
- Use calculus to derive constant acceleration formulae.
- (Know how to use initial conditions to calculate the constant of integration and refer back to the original problem)

Suggested time scale: 6 - 7 lessons

Misconceptions

Students who draw sketches of the situation are often more successful in reaching the correct solution, so you should continue to encourage this wherever possible.
Students often ignore or don't recognise the difference between displacement and distance and so may end up discarding negative values without considering how they should be interpreted.
Students can easily forget that if the velocity becomes negative, for example when a particle stops and changes direction, they need to split the integral to calculate distance rather than displacement.

Key Words Tier 2

Express, condition, area, draw, sketch.

Key Words Tier 3

Distance, displacement, velocity, speed, constant acceleration, variable acceleration, retardation, deceleration, gradient, area, differentiate, integrate, rate of change, straight-line motion, with respect to time, constant of integration, initial conditions.

Homework

Book 1 Mixed exercise Unit 11
Mathsgenie website: Variable Acceleration

Career links

R & D Engineer

Employability skills

Aiming high	Literacy	Creativity	Numeracy
Leadership	Independence	Listening	Communication
Presenting	Teamwork	Problem solving	Staying positive
Critical thinking	Analytical thinking	Time management	

Assessment:

Kinematics 2 (variable acceleration)

Year 13 Applied

Regression, correlation and hypothesis testing

Objectives. Students are expected to learn:

- Understand exponential models in bivariate data.
- Be able to change the variable in a regression line to estimate coefficients in an exponential model.
- Understand correlation coefficients and be able to calculate product moment correlation coefficient (PMCC - calculator only).
- Interpret a correlation coefficient using a given p-value or critical value (calculation of correlation coefficients is excluded).
- Be able to conduct a hypothesis test for a correlation coefficient.

Suggested time scale: 3 - 4 lessons

Misconceptions

Notation and stating a conclusion are the most common errors: 'some students failed to state their hypotheses in terms of ρ. Common errors include failing to ensure that critical values match the alternative hypothesis and giving conclusions that do not include a reference to the context.

Key Words Tier 2

Assume, explain, interpret, sample, alternative, critical.

Key Words Tier 3

Hypotheses, significance level, one-tailed test, two-tailed test, test statistic, null hypothesis, alternative hypothesis, critical value, critical region, acceptance region, p-value, binomial model, correlation coefficients, product moment correlation coefficient, population coefficient, inference, mean, normal distribution, variance, assumed variance, linear regression, interpolation, extrapolation, coded data

Homework

Book 2 Mixed exercise Unit 1

Mathsgenie website: Correlation Hypothesis Testing, Non Linear Regression

Career links

Financial Software Developer, Financial Engineer

Employability skills

Aiming high	Literacy	Creativity	Numeracy
Leadership	Independence	Listening	Communication
Presenting	Teamwork	Problem solving	Staying positive
Critical thinking	Analytical thinking	Time management	

Assessment: Regression and correlation

Enrichment

1) Senior Maths Challenge on 1st October 2024

We are regular participants in the maths challenge competition, and students speak highly of the chance to solve mathematical puzzles. This reinforces the foundations of mathematics as a problem-solving activity, and develops the skills required later by university admissions departments.

2) Free online Transition to University Course – Advanced Mathematics support programme Transition to University Course

The Transition to University Course 2024 course is designed for students who are:
Currently in Year 13 or taking a gap year.
Studying A level Mathematics.
Planning to begin studying a degree in maths, engineering, sciences, or closely related subjects such as economics in 2024 (or choosing to defer their entry until 2025).

Conditional probability

Objectives. Students are expected to learn:

- Be able to use set notation for probability.
- Understand and be able to use conditional probability. P$(A|B)$ = P$(A|B')$ = P(A) and P$(B|A)$ = P$(B|A')$ = P(B).
- Solve conditional probability problems using two-way tables and Venn diagrams.
- Be able to use probability formulae to solve problems. P(A ∪ B) = P(A) + P(B) – P(A ∩ B) and P$(B|A)$ = $\frac{\mathrm{P}(B|A)}{P(A)}$.
- Modelling with probability, including critiquing assumptions made and the likely effect of more realistic assumptions.

Suggested time scale: 5 - 6 lessons

Misconceptions

Mistakes tend to involve the use of the conditional probability formula. For example, wrongly assuming independence and putting P(A) × P(B) rather than $\mathrm{P}(A \cap B)$ as the numerator or the incorrect probability in the denominator.

Students should be careful not to make assumptions for which there is no basis. For example assuming two events are independent without having evidence or reasons for such an assumption.

Key Words Tier 2

Event, union, intersection, complement, independent, random, conditional.

Key Words Tier 3

Sample space, exclusive event, complementary event, discrete random variable, continuous random variable, mathematical modelling, independent, mutually exclusive, Venn diagram, tree diagram, set notation, conditional probability, two-way tables, critiquing assumptions.

Homework

Book 2 Mixed exercise Unit 2

Mathsgenie website: Probability

Career links

Quantitative Analyst, Quantitative Research Analyst

Employability skills

Aiming high	Literacy	Creativity	Numeracy
Leadership	Independence	Listening	Communication
Presenting	Teamwork	Problem solving	Staying positive
Critical thinking	Analytical thinking	Time management	

Assessment:

Conditional Probability

The normal distribution

Objectives. Students are expected to learn:

- Understand the properties of the Normal distribution. Knowledge of the shape and the symmetry of the normal distribution curve is required.
- Find percentage points and probabilities using the normal distribution
- Calculate values on a standard normal curve.
- Find unknown means and/or standard deviations for a normal distribution (questions may involve the solution of simultaneous equations).
- Know the points of inflection of a normal distribution are at $x = \mu \pm \sigma$ (do not need to derive).
- Know when and how to approximate a binomial distribution using a normal distribution.
- Select an appropriate probability distribution for a context, with appropriate reasoning, including recognising when the Binomial or Normal model may not be appropriate.
- Conduct a statistical hypothesis test for the mean of a normal distribution with known, given or assumed variance and interpret the results in context.

Suggested time scale: 9 - 10 lessons

Misconceptions

Main errors are due to confusion between probabilities and Z values, particularly when it comes to notation, and not using the full four decimal place accuracy in calculations.
An emphasis on using diagrams alongside the calculations should help address some of the difficulties.
Correctly applying continuity corrections can prove difficult with students either not applying one or otherwise adding 0.5 rather than subtracting or vice versa.
Common errors in exam situations include: not expressing hypotheses precisely enough; using an incorrect parameter or not using a parameter at all; incorrectly applying the continuity correction; and not giving a conclusion or answer to the question using the given context.

Key Words Tier 2

Population, symmetrical, distribution, parameters.

Key Words Tier 3

Binomial, discrete distribution, discrete random variable, uniform, cumulative probabilities Normal, mean, variance, continuous distribution, histogram, inflection, appropriate probability distribution.

Homework

Book 2 Mixed exercise Unit 3
Mathsgenie website: The Normal Distribution, Mean of Normal Distribution Hypothesis Testing, Using the Normal Distribution to approximate the Binomial

Career links

Government research and laboratories, market researcher

Employability skills

Aiming high	Literacy	Creativity	Numeracy
Leadership	Independence	Listening	Communication
Presenting	Teamwork	Problem solving	Staying positive
Critical thinking	Analytical thinking	Time management	

Assessment: **The normal distribution**

Moments
Objectives. Students are expected to learn: • Be able to calculate the turning effect of a force applied to a rigid body. • Be able to calculate the resultant moment of a set of forces acting on a rigid body. • Solve problems involving uniform rods in equilibrium. • Solve problems involving non-uniform rods. • Solve problems involving rods on the point of tilting. Suggested time scale: 5 - 6 lessons
Misconceptions Many students made their life more difficult than necessary by not taking the easy resolving option and using two moments equations resulting in simultaneous equations which can be difficult to solve. Clear diagrams can help to overcome some errors such as using distances from the wrong point or missing forces (often the weight). Students should also be reminded to read the question carefully and give their answer in the correct form – being particularly careful not to mix up weight and mass.
Key Words Tier 2 Clockwise, anti-clockwise, sum, direction, support, string.
Key Words Tier 3 Moment, turning effect, sense, Newton metre (N m), equilibrium, reaction, tension, rod, uniform, non-uniform, centre of mass, resolve, tilting, 'on the point', concurrent.
Homework Book 2 Mixed exercise Unit 4 Mathsgenie website: Moments
Career links Space/aircraft industry
Employability skills Aiming high — Literacy — Creativity — Numeracy Leadership — Independence — Listening — Communication Presenting — Teamwork — Problem solving — Staying positive Critical thinking — Analytical thinking — Time management
Assessment: **Moments**

Forces and friction

Objectives. Students are expected to learn:

- Be able to resolve forces into components and the use of the triangle law.
- Resolving forces in 2-dimension, equilibrium of a particle under coplanar forces.
- Solve problems involving smooth and rough inclined planes. (Resolve parallel to and at right angles to the plane).
- Understand and be able to use the coefficient of friction; motion of a body on a rough surface; limiting friction and statics.
- Understand and use the F $\leq \mu R$ model for friction.

Suggested time scale: 4 - 5 lessons

Misconceptions

When resolving common errors are: to omit g; sign errors; reversal or confusion* of when to use cos and/or sin; to omit one force (usually weight).
Students may also easily get confused by the vocabulary and mix up 'resultant' and 'reaction'.
Students are often good at drawing force diagrams, but common errors are omitting arrowheads, incorrectly labelling (e.g. 4 kg rather than 4g) and missing off the normal reaction or friction forces. Students can sometimes struggle to work out the direction of the frictional force.
Some students may mistakenly think that the coefficient of friction changes if the mass of an object or the angle of the slope changes.

Key Words Tier 2

Apply, direction, component, tension, light, smooth, rough, negligible.

Key Words Tier 3

Force, weight, thrust, friction, coefficient of friction, μ, limiting, reaction, resultant, magnitude, direction, bearing, force diagram, equilibrium, inextensible, particle, uniform, perpendicular.

Homework

Book 2 Mixed exercise Unit 5
Mathsgenie website: Resolving Forces, Resolving Forces 2

Career links

Quality Assurance Engineer

Employability skills

Aiming high	Literacy	Creativity	Numeracy
Leadership	Independence	Listening	Communication
Presenting	Teamwork	Problem solving	Staying positive
Critical thinking	Analytical thinking	Time management	

Assessment:

Forces at an angle

Projectiles

Objectives. Students are expected to learn:

- Be able to resolve velocity into horizontal and vertical components.
- Be able to find the time of flight of a projectile.
- Be able to find the range and maximum height of a projectile.
- Be able to derive formulae to find the greatest height, the time of flight and horizontal range (for a full trajectory).
- Know how to modify projectile equations to take account of the height of release.
- Be able to derive and use the equation of the path of a projectile.
- Be able to model motion under gravity in a vertical plane using vectors.

Suggested time scale: 5 - 6 lessons

Misconceptions

Students often find projectile questions challenging, sometimes confusing the horizontal and vertical aspects of the motion, for example by including the horizontal component of velocity in an equation for the vertical motion.
Other common mistakes include considering only one component of velocity when finding speeds and making sign errors when producing quadratic equations (to find t).

Key Words Tier 2

Model, component, project, range.

Key Words Tier 3

Projectile, vertical, horizontal, component, acceleration, gravity, initial velocity, vector, angle of projection, position, trajectory, parabola.

Homework

Book 2 Mixed exercise Unit 6
Mathsgenie website: Projectiles

Career links

Civil and structural engineer

Employability skills

Aiming high	Literacy	Creativity	Numeracy
Leadership	Independence	Listening	Communication
Presenting	Teamwork	Problem solving	Staying positive
Critical thinking	Analytical thinking	Time management	

Assessment:

Applications of kinematics (Projectiles)

Applications of forces

Objectives. Students are expected to learn:

- Understand that a body is in equilibrium under a set of concurrent (acting through the same point) forces if their resultant force is zero.
- Know that vectors representing forces in equilibrium form a closed polygon.
- Understand how to solve problems involving equilibrium of a particle under coplanar forces, including particles on inclined planes and 2D vectors.
- Be able to solve statics problems for a system of forces which are not concurrent (e.g. ladder problems), thus applying the principle of moments for forces at any angle.

- Know and understand the meaning of Newton's second law.
- Be able to formulate the equation of motion for a particle in 1 – and 2 - dimensional motion where the resultant force is mass x acceleration.
- Be able to formulate and solve separate equations for connected particles, where one particle could be on an inclined and/or rough plane.

Suggested time scale: 7 - 8 lessons

Misconceptions

Students are often good at drawing force diagrams, but common errors are omitting arrowheads, incorrectly labelling (e.g. 4 kg rather than 4g) and missing off the normal reaction or friction forces. Students can sometimes struggle to work out the direction of the frictional force.
Common errors in questions involving moments are ignored the weight of the ladder, sine/cosine confusion and missing a distance in one or more terms.
Common errors candidates make include: confusing the terms 'resultant' and 'reaction'; incorrectly treated the scenario as a statics problem and assuming the forces are in equilibrium; omitting g from the weight term; and, more rarely, including g in the 'ma' term.

Key Words Tier 2

Act, consider, limit, opposite, apply, direction, component, tension, light, smooth, rough, negligible.

Key Words Tier 3

Force, resultant, component, resolving, plane, parallel, perpendicular, weight, tension, thrust, friction, air resistance, reaction, driving force, braking force, force diagram, equilibrium, inextensible, light, negligible, particle, rough, smooth, incline, uniform, friction, coefficient of friction, concurrent, coplanar.

Homework

Book 2 Mixed exercise Unit 7
Mathsgenie website: Connected Particles, Statics of Rigid Bodies

Career links

Mechanical Maintenance Engineer

Employability skills

Aiming high	Literacy	Creativity	Numeracy
Leadership	Independence	Listening	Communication
Presenting	Teamwork	Problem solving	Staying positive
Critical thinking	Analytical thinking	Time management	

Assessment:

Applications of forces

Further kinematics
Objectives. Students are expected to learn: • Work with vectors for displacement, velocity and acceleration when using the vector equations of motion. • Use calculus (differentiation and integration) with harder functions of time involving variable acceleration. • Differentiate and integrate vectors with respect to time. Suggested time scale: 5 - 6 lessons
Misconceptions Candidates are generally able to use suvat equations in 2D to find unknown heights, velocities etc. However, some common errors are: finding a solution in vector form and not extracting one component e.g. to find the height; incorrectly finding velocity rather than speed and vice versa; and equating scalars and vectors and forgetting to split e.g. velocities into i and j components. Some common errors students make include: forgetting the constant of integration; giving the final answer as a vector when the question asked for the speed; and not being careful about changes of direction and so, for example, finding the displacement rather than the distance travelled.
Key Words Tier 2 Component, turning point, express, condition, area.
Key Words Tier 3 Distance, displacement, speed, velocity, constant acceleration, constant force, variable force, variable acceleration, retardation, deceleration, initial (t=0), stationary (speed=0), at rest (speed= 0), instantaneously, differentiate, integrate.
Homework Book 2 Mixed exercise Unit 8 Mathsgenie website: Kinematics with Vectors, Kinematics with Calculus
Career links Medical Engineering
Employability skills Aiming high — Literacy — Creativity — Numeracy Leadership — Independence — Listening — Communication Presenting — Teamwork — Problem solving — Staying positive Critical thinking — Analytical thinking — Time management
Assessment: **Further Kinematics**