6.9 MECHANICS 1, M1 (4761) AS

Objectives

To introduce students to mathematical modelling and to the basic concepts in kinematics, statics and dynamics which underlie the study of mechanics.

Students will be expected to formulate models, using the mechanics within the specification, and to show an appreciation of any assumptions made; they will also be expected to make simple deductions from the model and to comment on its usefulness. They will understand the particle model.

The examination will test candidates' knowledge of principles without excessive emphasis on algebraic or calculus skills.

Assessment

Examination (72 marks)
1 hour 30 minutes
The examination paper has two sections:

Section A: 5 - 7 questions, each worth at most 8 marks.
Section Total: 36 marks

Section B: two questions, each worth about 18 marks.
Section Total: 36 marks

In the written papers, unless otherwise specified the value of the acceleration due to gravity should be taken to be exactly 9.8 ms^{-2}.

Assumed Knowledge

Candidates are expected to know the content of *C1* and *C2*.

Calculators

In the MEI Structured Mathematics specification, no calculator is allowed in the examination for *C1*. For all other units, including this one, a graphical calculator is allowed.

MECHANICS 1, M1		
Specification	**Ref.**	**Competence Statements**
MODELLING		
		This section is fundamental to all the mechanics specifications
The modelling cycle applied to real-world problems.	M1p1	Understand the concept of a mathematical model.
	2	Be able to abstract from a real world situation to a mathematical description (model).
	3	Know the language used to describe simplifying assumptions.
	4	Understand the particle model.
	5	Be able to analyse the model appropriately.
	6	Be able to interpret and communicate the implications of the analysis in terms of the situation being modelled.
	7	Appreciate the importance of a check against reality.
	8	Appreciate that a model may need to be progressively refined.
S.I. Units.	9	Know the relevant S.I. units.
VECTORS		
The properties of vectors and techniques associated with them in 2 or 3 dimensions.	M1v1	Understand the language of vectors.
	2	Be able to find the magnitude and direction of a vector given in component form.
	3	Be able to express a vector in component form given its magnitude and direction.
	4	Be able to carry out elementary operations on vectors.
	5	Be able to apply vectors to mechanics problems.

MECHANICS 1, M1			
Ref.	**Notes**	**Notation**	**Exclusions**

MODELLING

This section is fundamental to all the mechanics specifications

M1p1	Flow chart on page 35.		
2			
3	The words: light; smooth; uniform; particle; inextensible; thin; rigid.		
4			
5	Manipulation of the mathematical model.		
6	The implications in real world terms. The need for estimation of accuracy.		
7	A modelling exercise which is not in some way checked against reality is of little or no value.		
8			
9	Metre (m), kilogram (kg), second (s), metre/second (ms^{-1}), metre/second/second (ms^{-2}), newton (N).		

VECTORS

M1v1	Vector, scalar, unit vector, position vector, component, magnitude, direction, resultant.	Vectors printed in **bold**. Unit vectors **i**, **j**, **k**. The magnitude of the vector **a** is written $\lvert\mathbf{a}\rvert$ or a. Position vector $\overrightarrow{OP}$ or **r**.	
2		Column vector e.g. $\begin{pmatrix} 2 \\ 3 \\ -1 \end{pmatrix}$	The direction of a vector in 3 dimensions.
3			
4	Addition, subtraction, multiplication by a scalar carried out algebraically and geometrically.		Product of two vectors.
5	Problems involving motion and forces.		

MECHANICS 1, M1		
Specification	**Ref.**	**Competence Statements**
KINEMATICS		
Motion in 1 dimension.	M1k1	Understand the language of kinematics.
The accurate use of terminology.	2	Know the difference between position, displacement and distance.
	3	Know the difference between velocity and speed, and between acceleration and magnitude of acceleration.
Kinematics graphs.	4	Be able to draw and interpret kinematics graphs, knowing the significance (where appropriate) of their gradients and the areas underneath them.
The use of calculus in kinematics.	5	Be able to differentiate position and velocity with respect to time and know what measures result.
	6	Be able to integrate acceleration and velocity with respect to time and know what measures result.
The use of constant acceleration formulae.	7	Be able to recognise when the use of constant acceleration formulae is appropriate.
	8	Be able to solve kinematics problems using constant acceleration formulae and calculus.
Motion in 2 and 3 dimensions.	9	Understand the language of kinematics appropriate to motion in 2 and 3 dimensions.
	10	Be able to extend the scope of techniques from motion in 1 to that in 2 and 3 dimensions by using vectors.
	11	Be able to find the Cartesian equation of the path of a particle when the components of its position vector are given in terms of time.
	12	Be able to use vectors to solve problems in kinematics.

MECHANICS 1, M1			
Ref.	**Notes**	**Notation**	**Exclusions**
	KINEMATICS		
M1k1	Position, displacement, distance; speed, velocity; acceleration, magnitude of acceleration; relative velocity (in 1 dimension).		
2			
3			
4	Position-time, distance-time, velocity-time, speed-time, acceleration-time.		
5			Cases where the time dependency is not of polynomial form will not be tested in this module.
6			
7			
8			
9	Position vector; relative position.		
10	The use of calculus and the use of constant acceleration formulae.	$\mathbf{a} = \dot{\mathbf{v}} = \frac{\mathrm{d}\mathbf{v}}{\mathrm{d}t}, \mathbf{v} = \dot{\mathbf{r}} = \frac{\mathrm{d}\mathbf{r}}{\mathrm{d}t}$ $\mathbf{r} = \int \mathbf{v}\mathrm{d}t, \mathbf{v} = \int \mathbf{a}\mathrm{d}t,$ $\mathbf{s} = \mathbf{u}t + \frac{1}{2}\mathbf{a}t^2,$ $\mathbf{v} = \mathbf{u} + \mathbf{a}t,$ $\mathbf{s} = \frac{1}{2}(\mathbf{u} + \mathbf{v})t.$	Vector form of $v^2 - u^2 = 2as$.
11	At least one of the components will be a linear function of time.		Cases involving motion in 3 dimensions.
12			

MECHANICS 1, M1		
Specification	**Ref.**	**Competence Statements**
FORCE		
The identification of the forces acting on a body and their representation in a diagram.	M1d1	Understand the language relating to forces.
	2	Be able to identify the forces acting on a system and represent them in a force diagram.
Vector treatment of forces.	3	Be able to resolve a force into components and be able to select suitable directions for resolution.
	4	Be able to find the resultant of several concurrent forces by vector addition.
	5	Know that a body is in equilibrium under a set of concurrent forces if and only if their resultant is zero.
	6	Know that vectors representing forces in equilibrium form a closed polygon.
	7	Be able to formulate and solve equations for equilibrium by resolving forces in suitable directions, or by way of a polygon of forces.
NEWTON'S LAWS OF MOTION		
The application of Newton's laws of motion to a particle.	M1n1	Know and understand the meaning of Newton's three laws.
	2	Understand the term equation of motion.
	3	Be able to formulate the equation of motion for a particle in 1-dimensional motion.
	4	Be able to formulate the equation of motion for a particle in 2- and 3- dimensional motion.
	5	Be able to formulate and solve separate equations of motion for connected particles.
PROJECTILES		
The motion of a projectile.	M1y1	Be able to formulate the equations of motion of a projectile.
	2	Know how to find the position and velocity at any time of a projectile, including the maximum height and range.
	3	Be able to find the initial velocity of a projectile given sufficient information.
	4	Be able to eliminate time from the component equations that give the horizontal and vertical displacement in terms of time.
	5	Be able to solve problems involving projectiles.

MECHANICS 1, M1			
Ref.	**Notes**	**Notation**	**Exclusions**
	FORCE		
M1d1	Weight, tension, thrust, normal reaction (or normal contact force), frictional force, resistance.		Calculations involving coefficient of friction.
2			
3	e.g. horizontally and vertically or parallel and perpendicular to an inclined plane.		
4	Graphically or by adding components.		
5			
6			
7	Lami's Theorem may be used where appropriate.		
	NEWTON'S LAWS OF MOTION		
M1n1		$\mathbf{F} = m\mathbf{a}$.	Variable mass.
2			
3	Including motion under gravity.		
4			
5	e.g. simple pulley systems, trains.		
	PROJECTILES		
M1y1			Air resistance. Inclined plane.
2			Recall of formulae.
3			
4			
5			