6.11 MECHANICS 3, M3 (4763) A2

Objectives

To build on the work in *Mechanics 1* and *Mechanics 2,* further extending the range of mechanics concepts which students are able to use in modelling situations.

The examination questions will be designed to test candidates’ understanding of the principles involved and of when they should be applied, rather than a high degree of manipulative skill, but candidates will be expected to interpret simple expressions written in algebra and the language of calculus.

Assessment

Examination (72 marks)
1 hour 30 minutes
There will be four questions each worth about 18 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*, *C2*, *C3* and *C4* and *M1* and *M2*.

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 3, M3		
Specification	**Ref.**	**Competence Statements**

DIMENSIONAL ANALYSIS		
Dimensional consistency.	M3q1	Be able to find the dimensions of a quantity in terms of M, L, T.
	2	Understand that some quantities are dimensionless.
	3	Be able to determine the units of a quantity by reference to its dimensions.
	4	Be able to change the units in which a quantity is given.
	5	Be able to use dimensional analysis as an error check.
Formulating models using dimensional arguments.	6	Use dimensional analysis to determine unknown indices in a proposed formula.

CIRCULAR MOTION		
The language of circular motion.	M3r1	Understand the language associated with circular motion.
Modelling circular motion.	2	Identify the force(s) acting on a body in circular motion.
	3	Be able to calculate acceleration towards the centre of circular motion.
Circular motion with uniform speed.	4	Be able to solve problems involving circular motion with uniform speed.
Circular motion with non-uniform speed.	5	Be able to solve problems involving circular motion with non-uniform speed.
	6	Be able to calculate tangential acceleration.
	7	Be able to solve problems involving motion in a vertical circle.
	8	Identify the conditions under which a particle departs from circular motion.

MECHANICS 3, M3			
Ref.	**Notes**	**Notation**	**Exclusions**

DIMENSIONAL ANALYSIS

Ref.	Notes	Notation	Exclusions
M3q1	e.g. density, energy, momentum.	M, L, T, [ ]	
2			
3			
4	e.g. density from kgm^{-3} to gcm^{-3}.		
5			
6	e.g. for the period of a pendulum.		

CIRCULAR MOTION

Ref.	Notes	Notation	Exclusions
M3r1	The terms tangential, radial and angular speed, radial component of acceleration, tangential component of acceleration.	$\dot{\theta}$, ω for angular speed.	
2	Candidates will be expected to set up equations of motion in simple cases.	$v = r\dot{\theta}$ or $r\omega$.	
3	Using the expressions $\frac{v^2}{r}$ and $r\dot{\theta}^2$.		
4	e.g. a conical pendulum, a car travelling horizontally on a cambered circular track.		
5			
6	Tangential component of acceleration $= r\ddot{\theta}$. Use of Newton's 2^{nd} law in tangential direction.		
7	The use of conservation of energy, and of $F = ma$ in the radial direction.		
8	e.g. when a string becomes slack, when a particle leaves a surface.		

MECHANICS 3, M3		
Specification	**Ref.**	**Competence Statements**

HOOKE'S LAW		
Extension of an elastic string and extension or compression of a spring.	M3h1	Be able to calculate the stiffness or modulus of elasticity in a given situation.
	2	Be able to calculate the tension in an elastic string or spring.
	3	Be able to calculate the equilibrium position of a system involving elastic strings or springs.
	4	Be able to calculate energy stored in a string or spring.
	5	Be able to use energy principles to determine extreme positions.

SIMPLE HARMONIC MOTION		
The Simple Harmonic Motion equation and its solution.	M3o1	Recognise situations which may be modelled by SHM.
	2	Be able to recognise the standard form of the equation of motion of SHM and formulate it as appropriate.
	3	Be able to recognise the SHM equation expressed in non-standard forms and to transform it into the standard form by means of substitution.
	4	Recognise the solution of the SHM equation in the form $x = a\sin\left(\omega t + \varepsilon\right)$ and be able to interpret it.
	5	Recognise other forms of the solution of the SHM equation, and be able to relate the various forms to each other.
	6	Be able to select a form of the solution of the SHM equation appropriate to the initial conditions.
	7	Be able to verify solutions of the SHM equation using calculus.
	8	Be able to apply standard results for SHM in context.
Applications of Simple Harmonic Motion.	9	Be able to analyse motion under the action of springs or strings as examples of SHM.
	10	Be able to calculate suitable constants to model given data by SHM equations.

MECHANICS 3, M3			
Ref.	**Notes**	**Notation**	**Exclusions**

HOOKE'S LAW			
M3h1		$T = kx$ where k is the stiffness.	
2		Tension = $\frac{\lambda x}{l_0}$ where λ is the modulus of elasticity and l_0 the natural length.	
3	e.g. a weight suspended by a spring.		
4		$\frac{1}{2}\frac{\lambda x^2}{l_0}$ or $\frac{1}{2}kx^2$	
5	Application to maximum extension for given starting conditions in a system, whether horizontal or vertical.		

SIMPLE HARMONIC MOTION			
M3o1	Including approximate cases such as a pendulum.		
2	The form $\ddot{x} = -\omega^2 x$		
3	e.g. $\ddot{x} + cx = 0, \ddot{x} = -\omega^2 (x + k)$ x can represent variables such as angles and population size.		
4	The significance of the constants a, ω and ε should be understood.	a = amplitude, T = period = $\frac{2\pi}{\omega}$ ε = phase	Damped oscillations. Solution of the SHM equation other than by verification.
5	$x = a\cos(\omega t + \varepsilon)$, $x = A\sin\omega t + B\cos\omega t$	$a = \sqrt{(A^2 + B^2)}$	
6			
7	Differentiation of sine and cosine.		
8	e.g. $v^2 = \omega^2(a^2 - x^2)$, $T = \frac{2\pi}{\omega}$		
9			
10			

MECHANICS 3, M3		
Specification	**Ref.**	**Competence Statements**

SOLID BODIES AND PLANE LAMINAE		
Centre of Mass.	M3g1	* Be able to calculate the volume generated by rotating a plane region about an axis.
	2	Be able to use calculus methods to calculate the centre of mass of solid bodies formed by rotating a plane area about an axis.
	3	Be able to find the centre of mass of a compound body, parts of which are solids of revolution.
	4	Be able to use calculus methods to calculate the centres of mass of plane laminae.
	5	Apply knowledge of centres of mass to simple cases of equilibrium.

* *This topic also appears in C4. It is included here for completeness.*

MECHANICS 3, M3			
Ref.	**Notes**	**Notation**	**Exclusions**

SOLID BODIES AND PLANE LAMINAE			
M3g1	Rotation about the x- and y-axes only.		The use of non-cartesian coordinates.
2	e.g. hemisphere, cone.		Variable density.
3	By treatment as equivalent to a finite system of particles.		Pappus' theorems.
4			
5	Including composite bodies.		