6.12 MECHANICS 4, M4 (4764) A2

Objectives

To prepare students for more advanced courses at university by extending the use of calculus in mechanics.

Students will be expected to be technically competent in the use of calculus and to be able to apply it to a variety of situations.

Students are expected to apply the modelling principles detailed in *Mechanics 1* in the context of this module.

Assessment

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

Section A:	two compulsory questions, each worth about 12 marks. Section Total: 24 marks
Section B:	two compulsory questions, each worth about 24 marks. Section Total: 48 marks

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*, *C4*, *FP1* and *FP2* and *M1*, *M2* and *M3*.

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 4, M4		
Specification	**Ref.**	**Competence Statements**
VARIABLE FORCES		
Application of variable forces in 1 dimension.	M4d1	Be able to calculate measures involving variable forces, in given dynamic situations in 1 dimension.
	2	Be able to formulate and solve differential equations using an appropriate expression for acceleration.
VARIABLE MASS		
The application of Newton's Second Law to problems involving variable mass.	M4k1	Understand and apply Newton's 2nd Law in the form $F = \frac{\mathrm{d}}{\mathrm{d}t}(mv)$.
	2	Be able to set up and solve differential equations for situations involving variable mass.
STABILITY		
The stability of equilibrium of a system of particles where the position of each is determined by a single parameter.	M4d3	Know and apply the energy criteria for the stability of a system of particles.
	4	Appreciate that potential energy must be related to some fixed origin.

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MECHANICS 4, M4			
Ref.	**Notes**	**Notation**	**Exclusions**
	VARIABLE FORCES		
M4d1	Work, energy, power, impulse.	work $= \int F\mathrm{d}s$. energy $= \int P\mathrm{d}t$. impulse $= \int F\mathrm{d}t$. power $= Fv$.	
2	e.g. for the velocity of a particle falling in a resistive medium.	$a = \frac{\mathrm{d}v}{\mathrm{d}t} = \frac{\mathrm{d}^2 s}{\mathrm{d}t^2}$ $a = v\frac{\mathrm{d}v}{\mathrm{d}s}$	
	VARIABLE MASS		
M4k1			
2	e.g. the terminal speed of a raindrop falling through a mist. e.g. the motion of a rocket.		
	STABILITY		
M4d3	Use of gravitational or elastic potential energy.		
4			

MECHANICS 4, M4		
Specification	**Ref.**	**Competence Statements**
ROTATION OF A RIGID BODY		
Calculation of moment of inertia.	M4r1	Understand the concept of moment of inertia as the analogue of mass in rotational motion.
Rotation of a rigid body about a fixed axis.	2	Be able to calculate moments of inertia of simple plane shapes and solids of uniform density from first principles.
	3	Know and use the perpendicular and parallel axes theorems.
	4	Be able to calculate centres of mass and moments of inertia of bodies of variable density and of compound bodies.
The equation of motion.	5	Be able to formulate the equation of motion of a rigid body about a fixed axis.
Kinetic energy of rotation.	6	Be able to apply the principle of conservation of energy to rotational motion of a rigid body.
	7	Be able to determine the period of small oscillations of a compound pendulum.
Angular momentum.	8	Be able to calculate the angular momentum of a rigid body and understand its significance.
Conservation of angular momentum.	9	Understand the conditions under which angular momentum is conserved, and apply the principle of conservation of angular momentum.
Motion following an impulsive blow.	10	Know how to calculate the angular velocity of a rotating body immediately after an impulsive blow.

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MECHANICS 4, M4			
Ref.	**Notes**	**Notation**	**Exclusions**
	ROTATION OF A RIGID BODY		
M4r1		$I = \sum mr^2$	
2			
3			
4			
5		$L = I\ddot{\theta}$	
6		$\text{KE} = \frac{1}{2} I\dot{\theta}^2$	
7		Angular momentum = $I\dot{\theta}$	
8	e.g. a bullet striking a rigid body suspended from a fixed axis e.g. a ring threaded on a smooth rotating rod.		
9			
10			