## 6.10 MECHANICS 2, M2 (4762) A2

### Objectives

To build on the work in *Mechanics 1* by extending the range of mechanics concepts which students are able to use in modelling situations. Students will be able to use the rigid body model in simple cases involving moments.

Students will be expected to formulate models, using the mechanics within this specification and that for *Mechanics 1*, 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.

The examination will test candidates' knowledge of principles and of when they should be applied. The examination will avoid excessive emphasis on algebraic or calculus skills, but candidates will be expected to interpret simple algebraic expressions.

### 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* and *C2* and *M1*.

### 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.

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| **Specification** | **Ref.** | **Competence Statements** |
| **FORCE** | | |
| Frictional force. | M2d1 | Understand that bodies in contact may be subject to a frictional force as well as a normal contact force (normal reaction), and be able to draw an appropriate force diagram. |
| | 2 | Understand that the total contact force between surfaces may be expressed in terms of a frictional force and a normal contact force (normal reaction). |
| | 3 | Understand that the frictional force may be modelled by $F \leq \mu R$ |
| | 4 | Be able to apply Newton's Laws to problems involving friction. |
| Rigid bodies in equilibrium subject to forces in two dimensions. | 5 | Be able to draw a force diagram for a rigid body. |
| | 6 | Understand that a system of forces can have a turning effect on a rigid body. |
| | 7 | Be able to calculate the moment about a fixed axis of a force acting on a body. |
| | 8 | Understand and be able to apply the conditions for equilibrium of a rigid body to the solution of problems. |
| | 9 | Be able to identify whether equilibrium will be broken by sliding or toppling in simple cases. |
| Light frameworks. | 10 | Be able to find the internal forces in a framework of light, pin-jointed rods by applying the conditions for equilibrium at the pin-joints. |
| | 11 | Be able to determine which rods in a framework are in compression and which in tension. |
| **WORK, ENERGY AND POWER** | | |
| Concepts of work and energy. | M2w1 | Be able to calculate the work done, both by a force which moves along its line of action and by a force which moves at an angle to its line of action. |
| | 2 | Be able to calculate kinetic energy. |
| | 3 | Understand the term mechanical energy. |
| The work-energy principle. | 4 | Understand the work-energy principle. |
| | 5 | Understand the terms conservative and dissipative forces. |
| | 6 | Be able to calculate gravitational potential energy. |
| | 7 | Be able to solve problems using the principle of conservation of energy. |
| Power. | 8 | Understand that the power of a force is the rate at which it does work. |
| | 9 | Be able to apply the concept of power to the solution of problems. |

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| **Ref.** | **Notes** | **Notation** | **Exclusions** |
| | **FORCE** | | |
| M2d1 | Smooth is used to mean frictionless. | | |
| 2 | | | |
| 3 | Limiting friction. | | The term angle of friction. |
| 4 | | | |
| 5 | In cases where the particle model is not appropriate. | | |
| 6 | e.g. simple levers. | | |
| 7 | Both as the product of force and perpendicular distance of the axis from the line of action of the force and by first resolving the force into components. | | Vector treatment. |
| 8 | The resultant of all the applied forces is zero and the sum of their moments about any axis is zero. Three forces in equilibrium must be concurrent. | | |
| 9 | e.g. a cube on an inclined plane. | | |
| 10 | | | |
| 11 | The term thrust may be used to describe a compression force. | | Bow's notation. |
| | **WORK, ENERGY AND POWER** | | |
| M2w1 | | | Continuously variable forces. **F.s** |
| 2 | | $\frac{1}{2}mv^2$ | |
| 3 | | | |
| 4 | The total work done by all the external forces acting on a body is equal to the increase in the kinetic energy of the body. | | |
| 5 | | | |
| 6 | Relative to some arbitrary zero level. | mgh | |
| 7 | e.g. the maximum height of some projectile, a particle sliding down a curved surface, a child swinging on a rope. | | |
| 8 | Power is Force x Speed in the direction of the Force. The concept of average power. | | |
| 9 | e.g. finding the maximum speed of a vehicle. | | |

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| **Specification** | **Ref.** | **Competence Statements** |
| **MOMENTUM AND IMPULSE** | | |
| Momentum and impulse treated as vectors. | M2i1 | Be able to calculate the impulse of a force as a vector. |
| | 2 | Understand the concept of momentum and appreciate that it is a vector quantity. |
| | 3 | Understand and be able to apply the Impulse-Momentum equation to problems. |
| Conservation of linear momentum. | 4 | Understand that a system subject to no external force conserves its momentum. |
| | 5 | Be able to derive the conservation of momentum equation for a collision between two particles in one dimension. |
| | 6 | Be able to apply the principle of conservation of momentum to direct impacts within a system of bodies. |
| Coefficient of restitution. | 7 | Understand Newton's Experimental Law and the meaning of coefficient of restitution, and be able to apply it in modelling impacts. |
| | 8 | Be able to solve problems using both momentum conservation and Newton's Experimental Law. |
| | 9 | Understand that mechanical energy is not conserved during impacts (unless $e = 1$) and be able to find the loss of mechanical energy. |
| Oblique impact with a smooth plane. | 10 | Understand that in an oblique impact between an object and a smooth plane, the impulse acts in a direction normal to the plane. |
| | 11 | Know that the velocity of the object parallel to the plane is unchanged by impact. |
| | 12 | Know that the direction of the component of the velocity perpendicular to plane is reversed and that its magnitude is multiplied by the coefficient of restitution. |
| | 13 | Be able to calculate the loss of kinetic energy in an oblique impact. |
| | 14 | Be able to solve problems involving oblique impact. |
| **CENTRE OF MASS** | | |
| Centre of a mass of a set of point masses. | M2G1 | Be able to find the centre of mass of a system of particles of given position and mass. |
| Centre of mass of simple shapes. | 2 | Appreciate how to locate centre of mass by appeal to symmetry. |
| Centre of mass of composite bodies. | 3 | Be able to find the centre of a mass of a composite body by considering each constituent part as a particle at its centre of mass. |
| Applications of the centre of mass. | 4 | Be able to use the position of the centre of mass in problems involving the equilibrium of a rigid body. |

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| | **MOMENTUM AND IMPULSE** | | |
| M2i1 | Impulse = Force x Time. | | The use of calculus for variable forces. |
| 2 | | | |
| 3 | The total impulse of all the forces acting on a body is equal to the change in momentum of the body. Problems may involve an understanding of relative velocity in one dimension. | | |
| 4 | | | |
| 5 | | | |
| 6 | e.g. colliding railway trucks. | | |
| 7 | e.g. between two spheres, or between a sphere and a wall. | *e* for coefficient of restitution. | |
| 8 | | | |
| 9 | | | |
| 10 | | | |
| 11 | | | |
| 12 | | | |
| 13 | | | |
| 14 | e.g. a ball bouncing following a projectile motion. | | |
| | **CENTRE OF MASS** | | |
| M2G1 | In 1, 2 and 3 dimensions. | $(\overline{x}, \overline{y}, \overline{z})$<br>$\left(\sum_i m_i\right)\overline{x} = \sum_i m_i x_i$ | Calculus methods. Non-uniform bodies. |
| 2 | Rod, rectangular lamina, circular lamina, cuboid, sphere. | | |
| 3 | Composite bodies may be formed by the addition or subtraction of parts.<br>Where a composite body includes parts whose centre of mass the candidate is not expected to know (e.g. triangle, semicircle, cone), the centre of mass will be given. | | |
| 4 | e.g. a suspended object or an object standing on an inclined plane. | | |