

Scheme of Work

Cambridge
International
AS & A Level

Cambridge International AS & A Level Mathematics

9709/05 Mechanics 2 (M2)

For examination from 2017



Contents

Introduction 3

1. Motion of a projectile 5

2. Equilibrium of a rigid body 6

3. Uniform motion in a circle 8

4. Hooke's law 9

5. Linear motion under a variable force 10

Introduction

This scheme of work provides ideas about how to construct and deliver a course. It has been broken down into different units of the three subject areas of Pure Mathematics (units P1, P2 and P3), Mechanics (units M1 and M2) and Probability & Statistics (units S1 and S2). For each unit there are suggested teaching activities and learning resources to use in the classroom for all of the syllabus learning objectives.

This scheme of work, like any other, is meant to be a guideline, offering advice, tips and ideas. It can never be complete but hopefully provides teachers with a basis to plan their lessons. It covers the minimum required for the Cambridge International AS & A Level course but also adds enhancement and development ideas. It does not take into account that different schools take different amounts of time to cover the Cambridge International AS & A Level course.

The mathematical content of Mechanics 2 in the syllabus is detailed in the tables below. The order in which topics are listed is not intended to imply anything about the order in which they might be taught.

Recommended prior knowledge

Knowledge of the content of unit M1 is assumed, and candidates may be required to demonstrate such knowledge in answering questions.

Candidates will be expected to be familiar with scientific notation for the expression of compound units, e.g. 5 m s^{-1} for 5 metres per second.

As well as demonstrating skill in the appropriate techniques, candidates will be expected to apply their knowledge in the solution of problems. Individual questions set may involve ideas and methods from more than one section of the relevant content list.

Outline

Suggestions for independent study (**I**) and formative assessment (**F**) are indicated, where appropriate, within this scheme of work. The activities in the scheme of work are only suggestions and there are many other useful activities to be found in the materials referred to in the learning resource list.

Opportunities for differentiation are indicated as **basic/consolidation** and **challenging/extension**. There is the potential for differentiation by resource, length, grouping, expected level of outcome, and degree of support by the teacher, throughout the scheme of work. Timings for activities and feedback are left to the judgment of the teacher, according to the level of the learners and size of the class. Length of time allocated to a task is another possible area for differentiation.

Teacher support

Teacher Support (<http://teachers.cie.org.uk>) is a secure online resource bank and community forum for Cambridge teachers, where you can download specimen and past question papers, mark schemes and other resources. We also offer online and face-to-face training; details of forthcoming training opportunities are posted online.

This scheme of work is available as PDF and an editable version in Microsoft Word format; both are available on Teacher Support at <http://teachers.cie.org.uk>. If you are unable to use Microsoft Word you can download Open Office free of charge from www.openoffice.org.

Resources

The up-to-date resource list for this syllabus, including textbooks endorsed by Cambridge, is listed at www.cie.org.uk

Endorsed textbooks have been written to be closely aligned to the syllabus they support, and have been through a detailed quality assurance process. As such, all textbooks endorsed by Cambridge for this syllabus are the ideal resource to be used alongside this scheme of work as they cover each learning objective.

Websites and videos

This scheme of work includes website links providing direct access to internet resources. Cambridge International Examinations is not responsible for the accuracy or content of information contained in these sites. The inclusion of a link to an external website should not be understood to be an endorsement of that website or the site's owners (or their products/services).

The website pages referenced in this scheme of work were selected when the scheme of work was produced. Other aspects of the sites were not checked and only the particular resources are recommended.

1. Motion of a projectile

Learning objectives	Suggested teaching activities
Model the motion of a projectile as a particle moving with constant acceleration and understand the limitations of the model.	There are some good ideas for class discussion on the modelling of projectiles here http://www.cimt.plymouth.ac.uk/projects/mepres/alevel/mechanics_ch5.pdf . Important points to bring out include the vector nature of velocity and the fact that the horizontal component of the velocity is constant since the only force being considered in the model is gravity.
Use horizontal and vertical equations of motion to solve problems on the motion of projectiles, including finding the magnitude and direction of the velocity at a given time or position, the range on a horizontal plane and the greatest height reached.	http://www.examsolutions.net/maths-revision/mechanics/kinematics/projectiles/tutorial-1.php has a video tutorial which sets out clearly the essential terminology and ideas for analysing projectile motion. This is the first in a series of tutorials which look at some different cases of projectile motion. You can find the others in the 'Projectiles' section at this link http://www.examsolutions.net/maths-revision/#Mechanics Past papers: (I)(F) June 2012 paper 52 question 5 June 2012 paper 53 question 1 June 2013 paper 51 question 5
Derive and use the Cartesian equations of the trajectory of a projectile, including problems in which the initial speed and/or angle of projection may be unknown.	http://www.cimt.plymouth.ac.uk/projects/mepres/alevel/mechanics_ch5.pdf has a clear explanation of the method for deriving the equation of the trajectory, although some of the notation goes a little beyond the objectives of this module. Also included are some useful discussion ideas and practical work to test the model, together with a useful set of problems for learners to solve. (I) Past papers: (I)(F) June 2012 paper 51 question 7 June 2012 paper 53 question 7 June 2013 paper 51 question 1

2. Equilibrium of a rigid body

Learning objectives	Suggested teaching activities
Calculate the moment of a force about a point, in two dimensional situations only (understanding of the vector nature of moments is not required).	<p>http://tap.iop.org/mechanics/static/203/page_46264.html has some good ideas for introducing the concept of moments, with practical activities that you can use to enhance understanding for learners. [Note: you should ignore any reference to “couples”.] (I)</p> <p>This video tutorial demonstrates how to calculate the moment of a force: http://www.examsolutions.net/maths-revision/mechanics/statics/moments/horizontal-rods/tutorial-1.php</p>
Use the result that the effect of gravity on a rigid body is equivalent to a single force acting at the centre of mass of the body, and identify the position of the centre of mass of a uniform body using considerations of symmetry.	<p>The first link above (http://tap.iop.org/mechanics/static/203/page_46264.html) has good practical activities which illustrate the concept of the centre of mass of an object.</p> <p>This video tutorial http://www.examsolutions.net/maths-revision/mechanics/centre-of-mass/laminas/symmetry/tutorial-1.php demonstrates the use of lines of symmetry to locate the centre of mass of uniform laminae. It may be helpful for learners to watch these two videos on systems of particles first: http://www.examsolutions.net/maths-revision/mechanics/centre-of-mass/particles/1D/tutorial-1.php and http://www.examsolutions.net/maths-revision/mechanics/centre-of-mass/particles/2D/tutorial-1.php.</p>
Use given information about the position of the centre of mass of a triangular lamina and other simple shapes.	<p>http://www.examsolutions.net/maths-revision/mechanics/centre-of-mass/laminas/triangle/tutorial-1.php is a video tutorial on centre of mass of a triangular lamina and http://www.examsolutions.net/maths-revision/mechanics/centre-of-mass/laminas/sector/tutorial-1.php covers sectors and semi-circles.</p> <p>You should make learners aware that formulae for centres of mass of some shapes are given to them in examinations. It would be good practice for you to show learners, at least the more mathematically confident, where these formulae come from.</p>
Determine the position of the centre of mass of a composite body by considering an equivalent system of particles (in simple cases only, e.g. a uniform L-shaped lamina).	<p>http://www.examsolutions.net/maths-revision/syllabuses/Index/period-1/Mechanics/module.php#CentreOfMass has a short series of video tutorials demonstrating the process involved in finding centres of mass of composite bodies and frameworks.</p> <p>Past papers: (I)(F) Most past paper questions on this topic will cover the next two objectives as well. Often, the first part of a question concerns locating the centre of mass of an object and then later parts of the question make use of it to solve problems. June 2012 paper 51 question 2</p>

Learning objectives	Suggested teaching activities
	<p>June 2012 paper 51 question 6 June 2012 paper 52 question 2 June 2012 paper 52 question 6</p>
<p>Use the principle that if a rigid body is in equilibrium under the action of coplanar forces then the vector sum of the forces is zero and sum of the moments of the forces about any point is zero, and the converse of this.</p>	<p>For equilibrium of a rigid body, the later parts of this document http://www.cimt.plymouth.ac.uk/projects/mepres/alevel/mechanics_ch9.pdf provide good examples and discussion points as well as questions for learners to try.</p> <p>You can find video tutorials here http://www.examsolutions.net/maths-revision/syllabuses/Index/period-1/Mechanics/module.php#CentreOfMass.</p> <p>For past papers see the previous objective.</p>
<p>Solve problems involving the equilibrium of a single rigid body under the action of coplanar forces, including those involving toppling or sliding (problems set will not involve complicated trigonometry).</p>	<p>The later parts of this document http://www.cimt.plymouth.ac.uk/projects/mepres/alevel/mechanics_ch9.pdf provide good examples and discussion points, as well as questions on toppling and sliding for learners to try.</p> <p>You can find video tutorials here http://www.examsolutions.net/maths-revision/syllabuses/Index/period-1/Mechanics/module.php#CentreOfMass.</p> <p>For past papers see the previous objective.</p>

3. Uniform motion in a circle

Learning objectives	Suggested teaching activities
Understand the concept of angular speed for a particle moving in a circle, and use the relation $v = r\omega$.	<p>This link http://tap.iop.org/mechanics/circular/223/page_46471.html provides some good ideas for practical activities which you can use with learners to bring out the most important ideas in circular motion. There are two other useful episodes at the same link.</p> <p>More mathematically confident learners may find the theoretical and mathematical background interesting. You can find useful material in this document http://www.cimt.plymouth.ac.uk/projects/mepres/alevel/mechanics_ch7.pdf (I)</p> <p>Past papers: (I)(F) June 2012 paper 51 question 1</p>
Understand that the acceleration of a particle moving in a circle with constant speed is directed towards the centre of the circle, and use the formulae $r\omega^2$ and $\frac{v^2}{r}$.	<p>This objective is also covered by the resources detailed above: http://tap.iop.org/mechanics/circular/223/page_46471.html for ideas on practical activities and http://www.cimt.plymouth.ac.uk/projects/mepres/alevel/mechanics_ch7.pdf for the theory.</p>
Solve problems which can be modelled by the motion of a particle moving in a horizontal circle with constant speed.	<p>For learners to be successful in these problems, you will need to help them to understand clearly what forces are involved in each problem and to choose the correct directions in which to resolve them. It is worth giving learners time to practise as many different situations as possible to give them wide experience in analysing the forces involved.</p> <p>Past papers: (I)(F) June 2012 paper 51 question 3 June 2012 paper 52 question 7 June 2013 paper 51 question 6 June 2013 paper 52 question 1</p>

4. Hooke's law

Learning objectives	Suggested teaching activities
Use Hooke's law as a model relating the force in an elastic string or spring to the extension or compression, and understand the term modulus of elasticity.	This link http://www.cimt.plymouth.ac.uk/projects/mepres/alevel/mechanics_ch6.pdf has good ideas for practical activities as well as all the theory and formulae, and many worked examples and exercises. The level of detail is enough to satisfy more mathematically curious and confident learners. (I) [Note: learners may come across different notation if they are also studying Physics.]
Use the formula for the elastic potential energy stored in a string or spring.	The document linked above http://www.cimt.plymouth.ac.uk/projects/mepres/alevel/mechanics_ch6.pdf also covers the derivation and use of the formula for elastic potential energy.
Solve problems involving forces due to elastic strings or springs, including those where considerations of work and energy are needed.	Past papers: (I)(F) June 2012 paper 51 question 4 June 2012 paper 52 question 3 June 2012 paper 53 question 4 and question 5

5. Linear motion under a variable force

Learning objectives	Suggested teaching activities
<p>Use $\frac{dx}{dt}$ for velocity, and $\frac{dv}{dt}$ or $v \frac{dv}{dx}$ for acceleration, as appropriate.</p>	<p>You can find notes with examples here http://www.physicsandmathstutor.com/maths-revision/a-level-mechanics-3/ (click on the 'Notes' link). Learners need to be clear that the two differential expressions for acceleration are equivalent, but the choice will depend on whether the variable is expressed with respect to t or x.</p>
<p>Solve problems which can be modelled as the linear motion of a particle under the action of a variable force, by setting up and solving an appropriate differential equation (restricted to equations in which the variables are separable).</p>	<p>You can find notes with examples here http://www.physicsandmathstutor.com/maths-revision/a-level-mechanics-3/ (click on the 'Notes' link).</p> <p>Past papers: (I)(F)</p> <p>June 2012 paper 51 question 5 June 2012 paper 52 question 1 and question 4 June 2012 paper 53 question 3 June 2013 paper 51 question 4 June 2013 paper 52 question 7</p>

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