Mechanics II Independent Revision Resource

**Specification points**

**3.4.1 Springs**

**(a)** tensile and compressive deformation; extension and compression

**(b)** Hooke’s law

**(c)** force constant *k* of a spring or wire; *F* = *kx*

**(d) (i)** force–extension (or compression) graphs for springs and wires

**(ii)** techniques and procedures used to investigate force–extension characteristics for arrangements which may include springs, rubber bands, polythene strips. **PAG2**

**3.4.2 Mechanical properties of matter**

**(a)** force–extension (or compression) graph; work done is area under graph

**(b)** elastic potential energy;

**(c)** stress, strain and ultimate tensile strength

**(d) (i)**

**(ii)** techniques and procedures used to determine the Young modulus for a metal **PAG2**

**(e)** stress–strain graphs for typical ductile, brittle and polymeric materials

**(f)** elastic and plastic deformations of materials including Investigating the properties of

Materials **PAG2**

**3.5.1 Newton’s laws of motion**

**(a)** Newton’s three laws of motion

**(b)** linear momentum; *p* = *mv*; vector nature of momentum

**(c)** net force = rate of change of momentum;

Learners are expected to know that *F = ma* is a special case of this equation.

**(d)** impulse of a force; impulse = *FΔt*

**(e)** impulse is equal to the area under a force–time graph.

Learners will also be expected to estimate the area under non-linear graphs. Using a spreadsheet to determine impulse from *F*–*t* graph.

**3.5.2 Collisions**

**(a)** the principle of conservation of momentum

**(b)** collisions and interaction of bodies in one dimension and in two dimensions. Two-dimensional problems will only be assessed at A level.

**(c)** perfectly elastic collision and inelastic collision.

|  |  |
| --- | --- |
| **Website** | **Comments** |
| <https://www.s-cool.co.uk/a-level/physics/deformation-solids> | Basic information about Hooke’s law and energy stored in springs. |
| <https://www.s-cool.co.uk/a-level/physics/momentum-and-impulse> | Momentum and impulse |
| <https://www.s-cool.co.uk/a-level/physics/stress-and-strain> | Stress, strain and Young Modulus explained in detail. |
| <https://revisionworld.com/a2-level-level-revision/physics-level-revision/force-motion/solid-materials> | All you need to know about materials (including composites and concrete – useful extra material for the budding engineer ☺) |
| <https://revisionworld.com/a2-level-level-revision/physics-level-revision/force-motion/under-stress> | More on Hooke’s law, stress, strain and the Young Modulus. |
| <http://www.a-levelphysicstutor.com/m-momimp-impulse.php#vect>  <http://www.a-levelphysicstutor.com/m-momimp-consvmtm.php>  <http://www.a-levelphysicstutor.com/m-kinetics-elastic-strngs.php>  <http://www.a-levelphysicstutor.com/matter-elasticity.php> | Advanced – with full derivations for those who want to go into more detail. Probably not a good site to go to if you are not studying Maths A level. |
| <http://www.a-levelphysicstutor.com/matter-props-defns.php> | Excellent Material’s definitions all in one place (and some extra ones we don’t cover for info) |
| [*http://www.a-levelphysicstutor.com/matter-types-solid.php*](http://www.a-levelphysicstutor.com/matter-types-solid.php) | *An extra one which is sadly not on the syllabus but Mrs K thinks is cool and will hopefully be interesting for the chemists among you.* |
| <https://www.youtube.com/watch?v=xrK4LCL8oZY&list=PLGvD8d3gDHUVgyxA8evex35dWdWpl47k3&index=7> | **YOUTUBE –** Momentum |
| <https://www.youtube.com/watch?v=Lh7Em7lg5aM&list=PLGvD8d3gDHUVgyxA8evex35dWdWpl47k3&index=11> | **YOUTUBE** – Young Modulus |
| <https://www.youtube.com/watch?v=S3qjFfXXUkI&list=PLGvD8d3gDHUVgyxA8evex35dWdWpl47k3&index=12> | **YOUTUBE –** Springs and Hooke’s Law |

|  |
| --- |
| **To Do**   * Create detailed revision notes from your text book and answer the end of section and practice questions. * Review the spec points above and ensure you have included everything * Use revision guides or the above websites/clips to help explain specific details * Make sure you know, understand and can describe the practical to determine Young Modulus (you might want to learn the one in the text book as it is easier to draw and describe. Also the experiments to determine the spring constant in series and parallel, plus fracture strength of a material.   Attempt past paper questions either repeating questions from your Study Booklet or **choose** from those below - MS in separate file at [Q:\Physics\A-Level\Module 3 - Forces and Motion\Revision resources\3 Mechanics C resources\Independent Revision Resource MS and examiner.docx](file:///Q:\Physics\A-Level\Module%203%20-%20Forces%20and%20Motion\Revision%20resources\3%20Mechanics%20C%20resources\Independent%20Revision%20Resource%20MS%20and%20examiner.docx) |

**Revision questions for Momentum, Impulse and Collisions**

**1.** A constant resultant horizontal force of 1.8 × 103 N acts on a car of mass 900 kg, initially at rest on a level road.

(a) Calculate

(i) the acceleration of the car,

.......................................................................................................................

.......................................................................................................................

(ii) the speed of the car after 8.0 s,

.......................................................................................................................

.......................................................................................................................

(iii) the momentum of the car after 8.0 s,

.......................................................................................................................

.......................................................................................................................

(iv) the distance travelled by the car in the first 8.0 s of its motion,

.......................................................................................................................

.......................................................................................................................

.......................................................................................................................

(v) the work done by the resultant horizontal force during the first 8.0 s.

.......................................................................................................................

.......................................................................................................................

(9)

(b) On the axes below sketch the graphs for speed, *v*, and distance travelled, *s*, against time, *t*, for the first 8.0 s of the car’s motion.



(2)

(c) In practice the resultant force on the car changes with time. Air resistance is one factor that affects the resultant force acting on the vehicle.  
You may be awarded marks for the quality of written communication in your answer.

(i) Suggest, with a reason, how the resultant force on the car changes as its speed increases.

.......................................................................................................................

.......................................................................................................................

.......................................................................................................................

.......................................................................................................................

(ii) Explain, using Newton’s laws of motion, why the vehicle has a maximum speed.

.......................................................................................................................

.......................................................................................................................

.......................................................................................................................

.......................................................................................................................

.......................................................................................................................

.......................................................................................................................

(5)

(Total 16 marks)

**2.** The diagram represents an experiment that can be used to investigate stopping distances for a moving trolley.



The trolley is placed on the raised section of the track. When released it moves down the track and then travels along the horizontal section before colliding with the block. The trolley and block join and move together after the collision. The distance they move is measured.

(a) State the main energy changes taking place

(i) as the trolley descends,

...........................................................................................................................

(ii) after the collision, as the trolley and block move together.

...........................................................................................................................

(2)

(b) Describe how the speed of the trolley, just before it collides with the block may be measured experimentally.

You may be awarded marks for the quality of written communication in your answer.

.....................................................................................................................................

.....................................................................................................................................

.....................................................................................................................................

.....................................................................................................................................

.....................................................................................................................................

.....................................................................................................................................

(3)

(c) State and explain how the speed of the trolley, prior to impact could be varied.

.....................................................................................................................................

.....................................................................................................................................

.....................................................................................................................................

(2)

(Total 7 marks)

**3.** The rate of change of momentum of a body falling freely under gravity is equal to its

**A** weight.

**B** power.

**C** kinetic energy.

**D** potential energy.

(Total 1 mark)

**4.** (a) State the principle of conservation of linear momentum for two colliding bodies.

.....................................................................................................................................

.....................................................................................................................................

.....................................................................................................................................

(2)

(b)



A bullet of mass 0.010 kg travelling at a speed of 200 m s–1 strikes a block of wood of mass 0.390 kg hanging at rest from a long string. The bullet enters the block and lodges in the block. Calculate

(i) the linear momentum of the bullet before it strikes the block,

...........................................................................................................................

(ii) the speed with which the block first moves from rest after the bullet strikes it.

...........................................................................................................................

...........................................................................................................................

(4)

(c) During the collision of the bullet and block, kinetic energy is converted into internal energy which results in a temperature rise.

(i) Show that the kinetic energy of the bullet before it strikes the block is 200 J.

...........................................................................................................................

(ii) Show that the kinetic energy of the combined block and bullet immediately after the bullet has lodged in the block is 5.0 J.

...........................................................................................................................

(iii) The material from which the bullet is made has a specific heat capacity of  
250 J kg–1 K–1. Assuming that all the lost kinetic energy becomes internal energy in the bullet, calculate its temperature rise during the collision.

...........................................................................................................................

...........................................................................................................................

...........................................................................................................................

(5)

(d) The bullet lodges at the centre of mass G of the block. Calculate the vertical height *h* through which the block rises after the collision.

.....................................................................................................................................

.....................................................................................................................................

.....................................................................................................................................

(2)

(Total 13 marks)

**5.** (a) An egg of mass 5.8 × 10–2 kg is dropped from a height of 1.5 m onto a floor. Assuming air resistance is negligible, calculate for the egg

(i) the loss of potential energy,

...........................................................................................................................

...........................................................................................................................

(ii) the kinetic energy just before impact,

...........................................................................................................................

(iii) the speed just before impact,

...........................................................................................................................

...........................................................................................................................

(iv) the momentum just before impact.

...........................................................................................................................

(7)

(b) On hitting the floor, the egg is brought to rest in a time of 0.010 s. Calculate the magnitude of the average decelerating force on the egg.

.....................................................................................................................................

.....................................................................................................................................

.....................................................................................................................................

(2)

(c) The egg is now placed in a container that crumples on impact. Explain why this type of container makes it far less likely that the egg will break.

.....................................................................................................................................

.....................................................................................................................................

.....................................................................................................................................

.....................................................................................................................................

(2)

(Total 11 marks)

**Revision questions for Materials topic**

**6.** (a) Describe an experiment to determine the Young modulus for a material in the form of a wire. Draw a labelled diagram and explain how you would make the necessary measurements. Show how you would use your measurements to calculate the result.

.....................................................................................................................................

.....................................................................................................................................

.....................................................................................................................................

.....................................................................................................................................

.....................................................................................................................................

.....................................................................................................................................

.....................................................................................................................................

.....................................................................................................................................

.....................................................................................................................................

.....................................................................................................................................

.....................................................................................................................................

.....................................................................................................................................

(8)

(b)



A copper wire and an aluminium wire, each of diameter 0.72 mm, are joined end to end as shown in the diagram with the aluminium wire fixed at right angles to a rigid support. A steadily increasing force, *F*, is applied. Use data from the Data Sheet to

(i) explain which wire will yield,

...........................................................................................................................

...........................................................................................................................

...........................................................................................................................

(ii) determine the value of F at which yield should occur.

...........................................................................................................................

...........................................................................................................................

...........................................................................................................................

...........................................................................................................................

...........................................................................................................................

(4)

(Total 12 marks)

**7.** A mass of 1500kg is attached to a cable and raised vertically by a crane. The graph shows how its velocity varies with time.



(a) Determine

(i) the initial uniform acceleration of the mass, ...................................................

...........................................................................................................................

...........................................................................................................................

(ii) the distance travelled by the mass while it is accelerating upwards.

...........................................................................................................................

...........................................................................................................................

...........................................................................................................................

(3)

(b) (i) Calculate the tension in the cable in the intervals

AB, ...................................................................................................................

...........................................................................................................................

...........................................................................................................................

...........................................................................................................................

CD. ...................................................................................................................

...........................................................................................................................

(ii) Stateinwhichintervalofthemotionthetensioninthecableisleast.

...........................................................................................................................

(4)

(c) Calculate the power supplied by the crane during the interval CD.

.....................................................................................................................................

.....................................................................................................................................

(2)

(Total 9 marks)

**8.** A student carries out an experiment to investigate how the extension of a steel wire varies with an increasing tensile force. The results of the experiment are shown plotted on the graph. The initial length of the wire is 0.50m and its diameter is 0.80 mm. The wire breaks at an extension of 1.46 mm.



Use information from the graph to determine

the Young modulus for the material,

...............................................................................................................................................

...............................................................................................................................................

...............................................................................................................................................

...............................................................................................................................................

...............................................................................................................................................

an estimate of the yield stress for the material.

...............................................................................................................................................

...............................................................................................................................................

**9.** (a) When determining the Young modulus for the material of a wire, a *tensile stress* is applied to the wire and the *tensile strain* produced is measured.

(i) State the meaning of

tensile stress .....................................................................................................

...........................................................................................................................

tensile strain .....................................................................................................

...........................................................................................................................

(ii) Define the Young modulus.

...........................................................................................................................

...........................................................................................................................

(3)

(b) The graph represents tensile stress-tensile strain curves for two different materials A and B. X and Y are the respective points at which each material fractures.



(i) One of the materials is brittle, the other ductile. State which material is brittle.

...........................................................................................................................

(ii) Making use of the curves in the graph, describe the behaviour of each material as it is stretched from its original state to breaking point.

material A .........................................................................................................

...........................................................................................................................

material B .........................................................................................................

...........................................................................................................................

(iii) State, giving a reason, which material has the greater value of the Young modulus.

...........................................................................................................................

...........................................................................................................................

(5)

(c) A vertical steel piano wire of length 1.5 m and cross-sectional area 1.3 × 10–6 m2 supports a load of 80N.

Given that the Young modulus for steel = 2.10 × 1011 Pa, calculate the extension in the wire produced by this load.

.....................................................................................................................................

.....................................................................................................................................

.....................................................................................................................................

(2)

(Total 10 marks)

**10.** (a) When a *tensile stress* is applied to a wire, a *tensile strain* is produced in the wire.   
State the meaning of

tensile stress, ...............................................................................................................

.....................................................................................................................................

tensile strain. ...............................................................................................................

.....................................................................................................................................

(2)

(b) A long, thin metal wire is suspended from a fixed support and hangs vertically.   
Masses are suspended from its lower end.

As the load on the lower end is increased from zero to a certain value, and then decreased again to zero, the variation of the resulting tensile strain with the applied tensile stress is shown in the graph.



(i) Describe the behaviour of the wire during this process. Refer to the points   
A, B, C and D in your answer.  
You may be awarded marks for the quality of written communication in your answer.

...........................................................................................................................

...........................................................................................................................

...........................................................................................................................

...........................................................................................................................

...........................................................................................................................

...........................................................................................................................

...........................................................................................................................

...........................................................................................................................

(ii) State, with a reason, whether the material of the wire is ductile or brittle.

...........................................................................................................................

...........................................................................................................................

(iii) What does AD represent?

...........................................................................................................................

(iv) State how the Young modulus for the material may be obtained from the graph.

...........................................................................................................................

(v) State how the energy per unit volume stored in the wire during the loading  
process may be estimated from the graph.

...........................................................................................................................

(9)

(c) The wire described in part (b) has an unstretched length of 3.0 m and cross-sectional area 2.8 × 10–7 m2. At a certain stage between the points A and B on the graph, the wire supports a load of 75 N. Calculate the extension produced in the wire by this load.   
the Young modulus for the material of the wire = 2.1 × 1011 Pa

.....................................................................................................................................

.....................................................................................................................................

.....................................................................................................................................

.....................................................................................................................................

(2)

(Total 13 marks)