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A LEVEL
Transition Guide

PHYSICS A

H556
For first teaching in 2015

KS5–HE Focus
Mechanics

Version 2

www.ocr.org.uk/physics

A LEVEL
PHYSICS A

Key Stage 5 to Higher Education Transition guides focus on how a particular topic is covered at the different key stages and provide information on:

- Differences in the demand and approach at the different levels;
- Useful ways to think about the content at Key Stage 5 which will help prepare students for progression to studying the subject in Higher Education;
- Common student misconceptions in this topic.

Transition guides also contain links to a range of teaching activities that can be used to deliver the content at Key Stage 5 to Higher Education and are designed to be of use to teachers of both key stages. Central to the transition guide is a Checkpoint task which is specifically designed to help teachers determine whether students have developed deep conceptual understanding of the topic at Key Stage 5 and assess their 'readiness for progression' to Higher Education content on this topic. This checkpoint task can be used as a summative assessment at the end of Key Stage 5 teaching of the topic or by Higher Education lecturers to establish their students' conceptual starting.

Key Stage 5 to Higher Education Transition Guides are written by lecturers at named Higher Education Institutes.

This Transition Guide has been developed in collaboration with John Perry from Keele University.

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Key Stage 5 Content

A Level Criteria Content:

- **Kinematics**
- **Dynamics**
- **Energy**
- **Momentum**
- **Circular motion**
  - radian measure of angle and angular velocity
  - application of F = ma = mv2/r = mrω2 to motion in a circle at constant speed.
- **Oscillations:**
  - simple harmonic motion;
  - quantitative treatment using $a = -\omega^2 x$ and its solution x =
  - A cosωt

First year HE Content (Keele)

Keele University Year 1 Indicative Content and Activities:

Mechanics: Laws of motion; Linear mechanics; Rotational mechanics; Conservation laws; Newton's law of Gravity; Orbits; Gauss's law applied to gravity; Special relativity

Mathematics: Introductory calculus: definition and rules of differentiation and integration; physical applications

Laboratory: Experiments in Physics (e.g. Gyroscopic Motion, Simple Harmonic Motion) and use of spreadsheet to analyse the experimental data.

Semester 1 Experimental Methods and Physics Skills

- The Range of Beta Particles in Aluminium
- **Simple Harmonic Motion : The Helical Spring**
- The Optical Spectrometer
- **Gyroscopic Motion**
- Gamma-ray Attenuation in Lead – Variation with Energy
- Attenuation of X-rays
- Emission Spectrum of Atomic Hydrogen and the Rydberg constant
- A Measurement of Cp/Cv for a Gas - Leybold
- Photoelectric Effect
- Determination of the Brewster Angle
- Electron diffraction and the measurement of Planck's constant
- Hall Effect
- Franck-Hertz experiment with neon

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Comment

Topic: Mechanics

The Keele University Year 1 Physics undergraduate course is structured around three main elements:

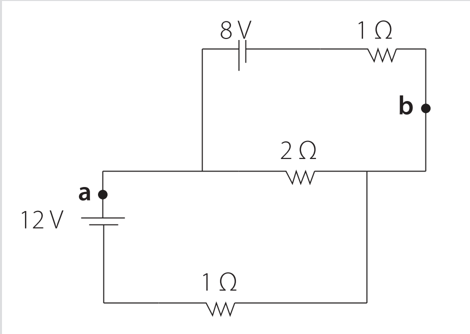
1. Lectures (full-group size)
2. Problem Classes (delivered in half-group size)
3. Experimental Methods and Physics Skills Module (full-group working in groups of two or three)

This is supplemented by a compulsory mathematics class that is differentiated by need.

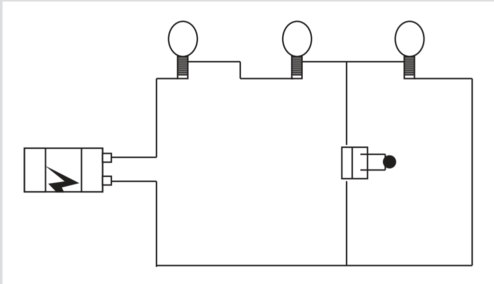
The Physics team see their new undergraduates as having no 'history'. They do not use any form of conceptual inventory to access the students as they start the course. Their Year 1 course is intended to establish basic concepts and skills, ready for Years 2 and 3, and an emphasis on learning to learn. They feel that even those with C grades at A Level can do well if they work hard and have the right attitude.

The Year 1 content is intended to link to A Level but delivered with a more problem solving approach. They feel that the A Level students often don't know how to tackle problems in a structured way – looking at the underlying physics first rather that going straight in for the numbers and finding a formula that will fit.

For example below:



1. In the circuit above, find the current through the 2 ohm resistor and the potential difference between point a and b.



2. In the circuit above, explain what will happen to the following variables when the switch is closed:
   - the current through the battery
   - the brightness of the bulbs
   - the voltage drop across the bulbs
   - the total power dissipated.

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It was felt by the staff that students would prefer Question 1, a mathematical process using Kirchhoff's Laws and simultaneous equations, to Question 2, that uses the same basic physics principles but requires a narrative response.

The table below, taken from the work of David Hammer (The Hammer Variables, 1996), was discussed with the course director:

	Favourable	Unfavourable
Independence	takes responsibility for constructing own understanding	takes what is given by authorities (teacher, text) without evaluation
Coherence	believes physics needs to be considered as a connected, consistent framework	believes physics can be treated as unrelated facts or independent 'pieces'
Concepts	stresses understanding of the underlying ideas and concepts	focuses on memorising and using formulas without interpretation or 'sense-making'

In practical sessions the new undergraduates appear to need a lot of help, wanting a step-by-step recipe rather than thinking through the task. The lab sessions are supported by 'demonstrators', who are usually PhD students, and an experienced lab technician. Comments from both indicate a view that the students have had little practical experience at A Level, are unsure how to write-up a lab report and have little experience of error calculations or how to consider the accumulative aspects of error. One of the aims of the lab sessions is to prepare the students for the small group projects in Year 2 and the individual project in Year 3. These projects are intended to prepare students for industry where they will often be employed to solve a problem and so have to devise their own methodology and consider what equipment they have, what they can use or what may have to be adapted.

With respect to the work of Year 2 and Year 3 teaching, staff attempt to relate theoretical concepts to practical/industrial applications. They often find that having a good A Level grade does not always guarantee a 'real world ' view of physics. This sometimes shows itself when students don't appear able to check their answers to calculations against the 'real world', they often accept the calculator answer. The ability to round up numbers and estimate an answer without the calculator is felt to be a weakness. It is felt that students have some appreciation of the difference between classical physics and the quantum world and this is an element that the team attempt to develop through Year 1.

Notes for all lectures are available on the University virtual learning environment but additional exemplar calculations will be done within the lecture. Students are expected to follow these through and there is the opportunity for interaction with the lecturer. Within the problem classes additional examples are given and worked through with solutions provided. Assessed problem sheets are also set which contribute to the final end of year grade.

With regard to Mechanics the following were considered as areas of weakness and misconception:

- the concept of force as an interaction - if A acts on B with a force X, then B acts on A with a force of magnitude X - see example 1
- when a force does not do work - object moving in a circular path - see example 2
- the relation of the equations of rotational motion to those of linear motion and in particular $F = ma$ and $\tau = I\alpha$

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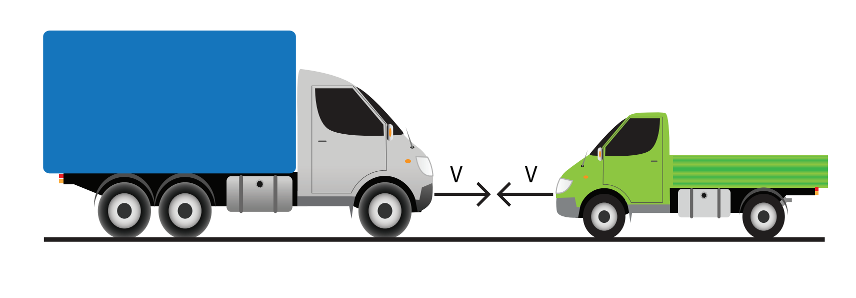
Example 1

In a head-on collision:



Which truck will experience the greatest force?

Which truck will experience the greatest impulse?

Which truck will experience the greatest change in momentum?

Which truck will experience the greatest change in velocity?

Which truck will experience the greatest acceleration?

Which truck would you rather be in during the collision?

Example 2

You are riding on a Ferris wheel that is rotating at constant speed.

Determine if the statements below are True or false:

During any fraction of a revolution:

(a) None of the forces acting on you does work on you.

(b) The total work done by all forces acting on you is zero.

(c) There is zero net force on you.

(d) You are accelerating.

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Activities

Hyperphysics

Resources: http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html

HyperPhysics is an exploration environment for concepts in physics which employs concept maps and other linking strategies to facilitate smooth navigation. For the most part, it is laid out in small segments or 'cards', true to its original development in HyperCard. The entire environment is interconnected with thousands of links, reminiscent of a neural network. The bottom bar of each card contains links to major concept maps for divisions of physics, plus a 'go back' feature to allow you to retrace the path of an exploration. The side bar contains a link to the extensive Index, which itself is composed of active links. That sidebar also contains links to relevant concept maps. The rationale for such concept maps is to provide a visual survey of conceptually connected material, and it is hoped that they will provide some answers to the question 'where do I go from here?'.

PhET
Resources: http://phet.colorado.edu/

PhET provides fun, interactive, research-based simulations of physical phenomena for free. We believe that our research-based approach, incorporating findings from prior research and our own testing, enables students to make connections between real-life phenomena and the underlying science, deepening their understanding and appreciation of the physical world.

To help students visually comprehend concepts, PhET simulations animate what is invisible to the eye through the use of graphics and intuitive controls such as click-and-drag manipulation, sliders and radio buttons. In order to further encourage quantitative exploration, the simulations also offer measurement instruments including rulers, stop-watches, voltmeters and thermometers. As the user manipulates these interactive tools, responses are immediately animated thus effectively illustrating cause-and-effect relationships as well as multiple linked representations (motion of the objects, graphs, number readouts, etc).

Teaching Advanced Physics
Resources: http://tap.iop.org/

This website contains detailed ideas and resources for teaching physics to students aged 16–19. The site aims to help those new to teaching this age group, and assumes only a limited access to equipment, resources, and advice from experienced colleagues. It is not intended to constrain the development of other equally valid approaches. The resources may be downloaded and adapted according to your own requirements. The site also gives a link to Practical Physics, a source of practical activities.

ISLE (Interactive Science Learning Environment)
Resources: http://www.islephysics.net/

An interactive method of teaching—Investigative Science Learning Environment (ISLE), involves students' development of their own ideas by:

(a) observing phenomena and looking for patterns,

(b) developing explanations for these patterns,

(c) using these explanations to make predictions about the outcomes of testing experiments,

(d) deciding if the outcomes of the testing experiments are consistent with the predictions, and

(e) revising the explanations if necessary.

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Perimeter Institute
Resources: http://www.perimeterinstitute.ca/about

Perimeter Institute is a leading centre for scientific research, training and educational outreach in foundational theoretical physics. Founded in 1999 in Waterloo, Ontario, Canada, its mission is to advance our understanding of the universe at the most fundamental level, stimulating the breakthroughs that could transform our future. Perimeter also trains the next generation of physicists through innovative programs, and shares the excitement and wonder of science with students, teachers and the general public.

An extensive video library available linked to modern physics.

National Physics Laboratory
Resources: http://www.npl.co.uk/

Two free guides to support practical work

NPL Guide 11: A Beginner's Guide to Uncertainty of Measurement

NPL Guide 36: Estimating Uncertainties in Testing

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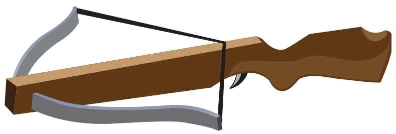
Checkpoint Tasks

Task 1

The pupils are set the task of determining the range for a given projectile fired from a toy crossbow that is inclined at 30o to the horizontal. There is a prize for the group that lands the projectile in a box positioned at their calculated point.

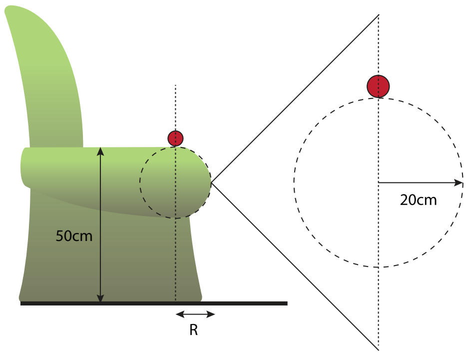


The pupils must establish the velocity of the crossbow dart as it leaves the bow. The small darts are weighted with a small amount of lead foil so that their range is limited.

Task 2

A person sitting in an armchair rolls a small ball off the chair as shown in the diagram below.

The part of the arm that the ball rolls down is circular in shape with a radius of 20 cm and the ball is released from the position shown. If the ball has a mass of 25 grams calculate the horizontal distance from the release point that the ball will hit the floor.



http://www.ocr.org.uk/Images/163776-mechanics-checkpoint-task-teacher-instructions.pdf

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Activities

Hyperphysics

Resources: http://www.flaguide.org/tools/diagnostic/force_concept_inventory.php
http://www.arborsci.com/60-questions-physics-students-should-know
http://www.fisica.uniud.it/girepseminar2001/GT/UCKE_GT3_FINAL.pdf

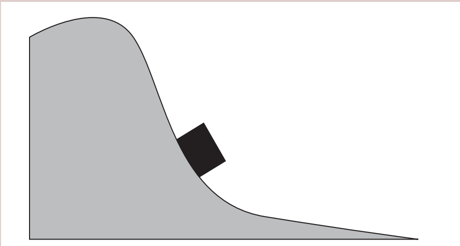
There are a number of concept inventories available from the internet that could be used as formal tests or as group discussion stimuli allowing peer to peer assessment. This follows the path of the work of Eric Mazur and his book Peer Instruction (Prentice Hall, 1997). Accompanying the book is a CD containing a number of concept inventories.

The mostly commonly known physics related concept inventory is the Force Concept Inventory (FCI) developed by Hestenes, Halloun, Wells, and Swackhamerthat tests the basic concepts in Newtonian mechanics. This can be obtained from the first weblink above.

Other question sets can be found, such as the '60 Questions you should know' from the second weblink above, that are intended to cover a wider range of topics.

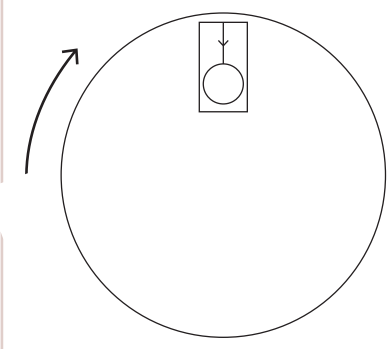
Example Questions

1. A cart on a roller-coaster rolls down the track shown below. As the cart rolls beyond the point shown, what happens to its speed and acceleration in the direction of motion?



(a) Both decrease.
(b) The speed decreases, but the acceleration increases.
(c) Both remain constant.
(d) The speed increases, but acceleration decreases.
(e) Both increase.
(f) Other.

2. A giant wheel, having a diameter of 40m, is fitted with a cage and platform on which a man of mass m stands. The wheel is rotated in a vertical plane at such a speed that the force exerted by the man on the platform is equal to his weight when the cage is at the highest point, as shown. The speed of the man is:

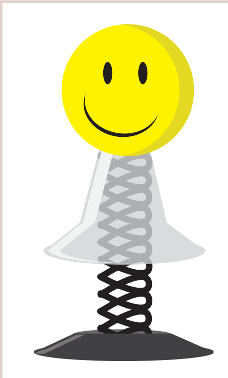


A. 14ms–1
B. 20ms–1
C. 28ms–1
D. 80ms–1
E. 120ms–1

3. Why when you release the toy in the normal position does it 'jump' higher than when you turn it upside down and release it? The toy needs to rest on a nut to support the rounded head.

Pupils could then experiment by loading the head or base with BluTac so changing the mass distribution.

A detailed version of this experiment can be found at the third weblink above.



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Activities

Internet Self Study

Resources: http://www.physics.umd.edu/rgroups/ripe/perg/ecs/phe.html
http://physicsweb.org/
http://www.pbs.org/opb/circus/classroom/circus-physics/center-mass/

The resources available from the first weblink above (University of Maryland Physics Education Research Group) allow a number of opportunities for A Level students to work independently, either individually or as part of a group.

The second weblink is to the IoP Physics World website that allows both teachers and pupils to look at current research work, and perhaps importantly for the A Level pupils to see where their studies could take them and that they are part of a worldwide 'physics family'. There are plenty of resources to extend topics and to look at applications of basic concepts.

The third weblink is an example link that looks at the physics of the circus. This video-based resource examines centre of mass, a concept that plays an important role in balance. The video explores the relationship between torque and centre of mass for a circus acrobat. The circus act involves two people: the bottom acrobat moves about the circus ring supporting the top acrobat, who balances on pointe upon her partner's head. When the top acrobat's centre of mass is not over the point of support, a torque results. Background information explains how to calculate torque (in terms of a simpler see-saw system). Also included are tips on how to incorporate the video into instruction, discussion questions, and accompanying classroom activities.

This would provide an excellent bridging activity between GCSE and A Level, allowing a range of initial mastery tasks for pupils, leading on to more complex development tasks.

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Contact the team: science@ocr.org.uk

Continue the discussion on the science community forum: http://social.ocr.org.uk/

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