Modify Unit

6293: SCIENCE - Physics HSC Modified: 04/04/2011 02:32pm (suz)

Title: Core - Space
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Unit Content | Resources | Assessments | Evaluation | Sense of the Sacred

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Overview:

Contextual Outline

Scientists have drawn on advances in areas such as aeronautics, material science, robotics, electronics, medicine and energy production to develop viable spacecraft. Perhaps the most dangerous parts of any space mission are the launch, re-entry and landing. A huge force is required to propel the rocket a sufficient distance from the Earth so that it is able to either escape the Earth's gravitational pull or maintain an orbit. Following a successful mission, re-entry through the Earth's atmosphere provides further challenges to scientists if astronauts are to return to Earth safely.

Rapid advances in technologies over the past fifty years have allowed the exploration of not only the Moon, but the Solar System and, to an increasing extent, the Universe. Space exploration is becoming more viable. Information from research undertaken in space programs has impacted on society through the development of devices such as personal computers, advanced medical equipment and communication satellites, and has enabled the accurate mapping of natural resources. Space research and exploration increases our understanding of the Earth's own environment, the Solar System and the Universe.

This module increases students' understanding of the history, nature and practice of physics and the implications of physics for society and the environment.

Reference:

BOS (2002) Physics Stage 6 Syllabus

BOS (2007) Science Stages 6 Revised Syllabus Support Document

Student Text:

Andriessen et al (2004), Physics 2 HSC Course (2nd Ed): Jacaranda

Text Chapters:

1: Earth's Gravitational Field

2: Launching into Space

3: Orbiting and Re-entry

4: Gravity in the Solar System

5: Space and Time

Outcomes:

A student:

H1	evaluates how major advances in scientific understanding and technology have changed the direction and nature of scientific thinking
H2	analyses the ways in which models, theories and laws in physics have been tested and validated
H3	assesses the impact of particular advances in physics on the development of technologies
H4	assesses the impacts of applications of physics on society and the environment
H5	identifies possible future directions of physics research
H6	explains events in terms of Newton's Laws, Law of Conservation of Momentum and relativity

H7	explains the effects of energy transfers and energy transformations
H8	analyses wave interactions and explains the effects of those interactions
H9	explains the effects of electric, magnetic and gravitational fields
H10	describes the nature of electromagnetic radiation and matter in terms of the particles
H11	justifies the appropriateness of a particular investigation plan
H12	evaluates ways in which accuracy and reliability could be improved in investigations
H13	uses terminology and reporting styles appropriately and successfully to communicate information and understanding
H14	assesses the validity of conclusions from gathered data and information
H15	explains why an investigation is best undertaken individually or as a team
H16	justifies positive values about, and attitude towards, both the living and non-living components of the environment, ethical behaviour and a desire for a critical evaluation of the consequences of the applications of science

Aim and Objectives

Students will develop knowledge and understanding of:

1. the history of physics
2. the nature and practice of physics
3. applications and uses of physics
4. the implications of physics for society and the environment
5. current issues, research and developments in physics
6. kinematics and dynamics
7. energy
8. waves
9. fields
10. matter.

Students will develop further skills in:

11. planning investigations
12. conducting investigations
13. communicating information and understanding
14. developing scientific thinking and problem-solving techniques
15. working individually and in teams.

Students will develop positive values about and attitudes towards:

16. themselves, others, learning as a lifelong process, physics and the environment.

Key Competencies:

Physics Stage 6 provides the context within which to develop general competencies considered essential for the acquisition of effective, higher-order thinking skills necessary for further education, work and everyday life.

Key competencies are embedded in the *Physics Stage 6 Syllabus* to enhance student learning and are explicit in the objectives and outcomes of the syllabus. The key competencies of ***collecting, analysing and organising information*** and ***communicating ideas and information*** reflect core processes of scientific inquiry and the skills identified in the syllabus assist students to continue to develop their expertise in these areas.

Students work as individuals and as members of groups to conduct investigations and, through this, the key competencies, ***planning and organising activities*** and ***working with others and in teams***, are developed. During investigations, students use appropriate information technologies and so develop the key competency of ***using technology***. The exploration of issues and investigation of problems contributes towards students' development of the key competency ***solving problems***. Finally, when students analyse statistical evidence, apply mathematical concepts to assist analysis of data and information and construct tables and graphs, they are developing the key competency ***using mathematical ideas and techniques.***

Skills

11.1a analyse complex problems to determine appropriate ways in which each aspect may be researched **11.1b** determine the type of data that needs to be collected and explain the qualitative or quantitative analysis that will be required for	**12.1a** carrying out the planned procedure, recognising where and when modifications are needed and analysing the effect of these adjustments **12.1b** efficiently undertaking the planned procedure to minimise

this data to be useful **11.2a** demonstrate the use of the terms ‘dependent’ and ‘independent’ to describe variables involved in the investigation **11.2b** identify variables that are needed to be kept constant, develop strategies to ensure that these variables are kept constant **11.2c** design investigations that allow valid and feliable data and information to be collected **11.3a** identifying and/or setting up the most appropriate equipment or combination of equipment needed to undertake the investigation **11.3c** identifying technology that would be used during investigation determining its suitability and effectiveness for its potential role in the procedure or investigation	hazards and wastage of resources **12.1c** disposing carefully and safely of any waste materials produced during the investigation **12.1d** identifying and using safe work practices during investigations **12.2a** using appropriate data collection techniques employing appropriate technologies, including data loggers and sensors **12.2b** measuring, observing and recording results in accessible and recognisable forms, carrying out repeat trials as appropriate **12.3a** accessing information from a range of resources, including popular scientific journals, digital technologies and the Internet **12.3b** practising efficient data collection techniques to identify useful information in secondary sources **12.3d** summarising and collating information from a range of resources **12.4c** best illustrate trends and patterns by selecting and using appropriate methods, including computer assisted analysis **12.4e** assess the reliability of first-hand and secondary information and data by considering information from various sources
13.1a selecting and using appropriate text types or combinations thereof, for oral and written presentations **13.1b** selecting and using appropriate media to present data and information **13.1c** selecting and using appropriate methods to acknowledge sources of information **13.1d** using symbols and formulae to express relationships and using appropriate units for physical quantities **13.1e** using a variety of pictorial representations to show relationships and present information clearly and succinctly	**14.1a** identify trends, patterns and relationships as well as contradictions in data and information **14.1b** justify inferences and conclusions **14.1c** identify and explain how data supports or refutes an hypothesis, a prediction or a proposed solution to a problem **14.1d** predict outcomes and generate plausible explanations related to the observations **14.1e** make and justify generalisations **14.1f** use models, including mathematical ones to explain

13.1f selecting and drawing appropriate graphs to convey information and relationships clearly and accurately	phenomena and/or make predictions **14.1g** use cause and effect relationships to explain phenomena **14.2b** describing and selecting from different strategies, those which could be used to solve a problem **14.2d** evaluating the appropriateness of different strategies for solving an identified problem

Students Learn To:	Students:	Teaching/Learning Strategies, Resources and References	Registration
1. The Earth has a gravitational field that exerts a force on objects both on it and around it			
1. Define weight as the force on an object due to a gravitational field. **2.** Explain that a change in gravitational potential energy is related to work done. **3.** Define gravitational potential energy as the work done to move an object from a very large distance away to a point	**4.** Perform an investigation and gather information to determine a value for acceleration due to gravity using pendulum motion or computer-assisted technology and identify reason for possible variations from the value 9.8 ms^{-2} **5.** Gather secondary information to predict	**<u>Resources:</u>** ▪ **Andriessen: Physics 2 3rd Edition – pp 13-15** ▪ **Timesaver Worksheets on Space 9.1 – 9.3** ▪ **Andriessen: Space, Learning Materials Production, OTEN – Part 1 p. 1** **4 (H6, H9, H12, H14)** • Introduction to topic through use of a concept map • Students undertake three experiments: - Using a pendulum to determine 'g' - Using a ticker timer to determine 'g'	

in a gravitational field $E_p = -G\frac{m_1 m_2}{r}$	the value of acceleration due to gravity on other planets. **6.** Analyse information using the expression: $F = mg$ to determine the weight force for a body on Earth and for the same body on other planets.	- Using a CBR to determine 'g **(12.1a; 12.2b)** • Students compare their answers with the accepted value of 9.8 $ms^{-2.}$ They then discuss which is the more reliable and accurate method to determine *'g'* **(14.3c)** Refer to: http://motivate.maths.org/conferences/conf86/c86_gexperiments.shtml **<u>Resources:</u>** **Andriessen: Physics 2 3rd Edition – pp 3-8** **1, 2, 5, 6 (H9, H12, H14, H16)** • Students use dictionaries to define: - Mass - Weight • Students recall the difference between mass and weight with reference to a rocket on earth and in outer space. • Students use simulators to find gravity on other planets - *the Planet Weight program.* Refer to: http://edmall.gsfc.nasa.gov/inv99Project.Site/Pages/gravity.html • Students read through notes, answer questions and perform calculations to compare weight forces on different planets. **(12.3c; 14.1f)**	

- Students compare weight on Earth and the Moon and investigate the role of the early astronauts in our understanding of this.

- Students gather secondary information to predict the value of acceleration due to gravity on other planets by:

1. Accessing information from a range of resources, including popular scientific journals, digital technologies and the Internet.
2. Practising efficient data collection techniques to identify useful information in secondary sources.
3. Extracting information from numerical data in graphs and tables as well as written and spoken material in all its forms. **(14.1a,d,f)**

- Students analyse information using the expression *F=mg* to determine the weight force for a body on Earth and for the same body on other planets by:

1. Identifying trends, patterns and relationships as well as contradictions in data and information.
2. Predict outcomes and generate plausible explanations related to the observations
3. Use models, including mathematical ones, to explain phenomena and/or make predictions

Resources:

- **Andriessen: Physics 2 – pp 7-9**
- **Timesaver worksheets – set 9.2**

3 (H7, H9)

- Following class discussion and with teacher guidance, deduce that gravitational potential energy changes as an object moves away from a planet and define the change in the gravitational potential energy as the

		work done to move an object from a very large distance away to a point in a gravitational field where $E_p = -G\frac{m_1 m_2}{r}$	
2. Many factors have to be taken into account to achieve a successful rocket launch, maintain a stable orbit and return to Earth			
7. Describe the trajectory of an object undergoing projectile motion within the Earth's gravitational field in terms of horizontal and vertical components. **8.** Describe Galileo's analysis of projectile motion. **9.** Explain the concept of escape velocity in terms of the: • gravitational constant • mass and radius of	**20.** Solve problems and analyse information to calculate the actual velocity of a projectile from its horizontal and vertical components using : $v_y^2 = u_y^2$ $v = u + at$ $v_y^2 = u_y^2 + 2a_y\Delta y$ $\Delta x = u_x t$ $\Delta y = u_y t + \frac{1}{2}a_y t^2$	<u>**Resources:**</u> ▪ **Andriessen: Physics 2 – pp 15-23** ▪ **Orbit Xplorer Program** ▪ ***Physics Problems for Senior Students*: Dyett - problems 25-28** ▪ ***Tutorial Problems in Senior Physics*: Humphrey – Set 17** **7, 21 (H2, H4, H6, H9, H11, H12, H14)** • Define the terms: - Projectile motion - Trajectory - Launch velocity - Maximum height reached - Range	

the planet **10.** Outline Newton's concept of escape velocity. **11.** Identify why the term 'g forces' is used to explain the forces acting on an astronaut during launch. **12.** Discuss the effect of the Earth's orbital motion and its rotational motion on the launch of a rocket. **13.** Analyse the changing acceleration of a rocket during launch in terms of the: • Law of Conservation of Momentum • forces experienced by astronauts **14.** Analyse the forces involved in uniform circular motion for a range of objects, including satellites	**21.** Perform a first-hand investigation, gather information and analyse data to calculate initial and final velocity, maximum height reached, range and time of flight of a projectile for a range of situations by using simulations, data loggers and computer analysis. **22.** Identify data sources, gather, analyse and present information on the contribution of one of the following to the development of space exploration: Tsiolkovsky, Oberth, Goddard, Esnault-Pelterie, O'Neill or von Braun. **23.** Solve problems and analyse information to calculate the	- Time of flight • Observe the relationship between the motion of a rocket and projectile motion, using, for example, a water rocket. Students collect data on launch angle, range and time of flight for: - Different launch angles - Different volumes of water in the rocket • Use the data from the experiment to determine the height reached and launch velocity. **(12.1a, b; 12.2b; 12.4b; 14.1f)** • Perform an experiment where a ball bearing is flicked off a bench onto the floor. Students measure the vertical drop and the range. Students use the data from the experiment to determine: - Time of flight - Launch velocity - Final velocity **(12.1a,b; 12.2b; 14.1f)** • Once the experiment has been performed, students evaluate ways in which the launch can be controlled so that reliable data can be collected. **(11.2b)** __**Resources:**__ ▪ **Andriessen: Physics 2 – pp 18-19**	

orbiting the Earth. **15.** Compare qualitatively low Earth and geo-stationary orbits. **16.** Define the term orbital velocity and the quantitative and qualitative relationship between orbital velocity, the gravitational constant, mass of the central body, mass of the satellite and the radius of the orbit using Kepler's Law of Periods. **17.** Account for the orbital decay of satellites in low Earth orbit. **18.** Discuss issues associated with safe re-entry into the Earth's atmosphere and landing on the Earth's surface.	centripetal force acting on a satellite undergoing uniform circular motion about the Earth using: $F = \frac{mv^2}{r}$ **24.** Solve problems and analyse information using: $\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$	**8 (H1, H2, H4, H5, H6)** • Students use secondary data to outline Galileo's analysis of projectile motion. • After teacher modelling of the method of combining and resolving vectors into components, students determine the velocity of a projectile from horizontal and vertical components. **<u>Resources:</u>** ▪ **Andriessen: Physics 2 – pp 27-30** **9, 10 (H4, H6, H9)** • Explain the concept of escape velocity through class discussion to produce a list of factors which are important in sending rockets/satellites into space and into orbit. Include forces of gravity, effect on astronaut, escape velocity, re-entry angle, friction on re-entry. • Use Newton's analysis of projectiles being thrown off towers. **<u>Resources:</u>** ▪ **Andriessen: Physics 2 – pp 20-26** **20 (H4, H6, H9, H12)** • Following teacher modelling of the derivation and usage of motion equations for projectile motion, students analyse information and solve problems using motion equations for projectile motion with particular application to the motion of objects in gravitational fields including,	

19. Identify that there is an optimum angle for safe re-entry for a manned spacecraft into the Earth's atmosphere and the consequences of failing to achieve this angle.		boomerangs and the use of woomeras. **(12.1a,b; 12.2b; 12.4b; 14.1f)** **<u>Resources:</u>** ▪ **Andriessen: Physics 2 – pp 28-38** **11,12 (H4, H6, H9, H14)** • Define the term g-force and explain why this term is used to explain the forces acting on an astronaut during launch. • After teacher demonstration and class discussion, analyse the change in the acceleration of a rocket, by identifying any relationship between the change in acceleration and any change to the force on the astronauts or momentum of the rocket. • After viewing or experiencing an appropriate stimulus, e.g. a fun park, video etc, students compare the forces on an astronaut during launch to what happens during a roller coaster ride. • Discuss the effect of the Earth's orbital motion and its rotational motion on the launch of a rocket by: 1. Identifying that the Earth has an atmosphere 2. Developing an analogy between launching a rocket with or against the atmosphere with a plane taking off or with the prevailing wind conditions. **<u>Resources:</u>** ▪ **Andriessen: Physics 2 – pp 29-38** **13 (H6, H9, H14)** • Recall the Law of Conservation of Momentum and Newton's Third Law of	

Motion. Apply these laws to

- The changing acceleration of a rocket launch
- The forces experienced by astronauts during launch
- Why equatorial sites use less energy.

22 (H1, H2, H3, H5, H13 H14)

- Students research three of the following scientists and their contribution to space exploration using both print and electronic media. Information is to be presented as a timeline and a descriptive report:

- Tsiolkovsky,
- Oberth,
- Goddard,
- Esnault-Pelterie,
- O'Neill or
- von Braun. **(11.1b; 12.3a,b; 13.1a,e; 14.1e)**

<u>Resources:</u>

- **Andriessen: Physics 2 – pp 61-62**

14, (H6, H9, H12)

- Perform and experiment to model the forces acting on a satellite orbiting the Earth. Students are given the experimental set-up but must identify the following:

		- The part simulating the Earth's gravitational force - The part simulating the satellite - The effect of increasing the orbital speed of the satellite - The effect of decreasing the orbital speed of the satellite. **(12.1a,b; 14.1d)** • Rotate an object on a string and note the change in speed of the object as the string is shortened and the tension is increased slightly, to demonstrate that the closer a satellite is to its parent body; the faster it moves to maintain a stable orbit. **Resources:** ▪ **Andriessen: Physics 2 – pp 47-60** **15, 16, 17, 23, 24 (H4, H6, H9, H12, H14)** • Distinguish between Low Earth orbits AND Geo-stationary orbits. • Use the equation $$F = \frac{mv^2}{r}$$	

to solve problems associated with:

- uniform circular motion
- how earth orbits
- geostationary orbits

(14.1f; 14.2a)

- Using teacher provided information on low earth and geostationary orbits compare qualitatively and quantitatively orbital characteristics such as velocity, radius and period.

- Get class outside, form a line with half facing one direction and the other half facing the opposite direction, link arms and then rotate the line. Get students to swap positions. Discuss observations.

- Define low earth orbit as ranging from 70km to 500km and discuss the density of the ionosphere and the dangers of flares on satellites.

- Explain how the Earth’s atmosphere affects the motion of “old” satellites and leads to ‘orbital decay’. Describe the effect of ‘orbital decay’ on the motion of the satellite.

- Outline Kepler’s Third Law – the Law of Periods and solve equations using:

$$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$$

<u>Resources:</u>

		▪ **Andriessen: Physics 2 – pp 53-58** **18, 19 (H4, H12, H13, H14)** • Watch videos of shuttle landings and replacement of tiles. • Discuss how and why in order to re-enter the Earth's atmosphere a spacecraft must deliberately lose velocity in such a way that it strikes the atmosphere at an optimum angle and the consequences if not attained. • Students make a list of some of the dangers of atmospheric re-entry with a short explanation of each.	
3. The Solar System is held together by gravity			
25. Describe a gravitational field in the region surrounding a massive object in terms of its effects on other masses in it. **26.** Define Newton's Law of Universal Gravitation:	**29.** Present information and use available evidence to discuss the factors affecting the strength of the gravitational force. **30.** Solve problems and analyse	<u>**Resources:**</u> ▪ **Heffernan: Physics Contexts 1: pp 8.1-8.2** ▪ **The Physics classroom:** http://www.physicsclassroom.com/Class/newtlaws/index.cfm **25, 26, 29 (H9, H13, H14)** • Students using their own knowledge brainstorm the development and current structure of the solar system. • Describe a gravitational field as the region of influence around any object	

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<td>$$F = G\frac{m_1 m_2}{d^2}$$

27. Discuss the importance of Newton's Law of Universal Gravitation in understanding and calculating the motion of satellites

28. Identify that a slingshot effect can be provided by planets for space probes.</td>
<td>information using:

$$F = G\frac{m_1 m_2}{d^2}$$</td>
<td>with mass.

• Define Newton's Law of Universal Gravitation

$$F = G\frac{m_1 m_2}{d^2}$$

• Discuss the effect of mass of the objects and the distance between them on the size of the gravitational field. **(13.1a,e; 14.3d)**

Resources:

▪ **Andriessen: Physics 2 – pp 50-52**
▪ **Heffernan: Physics Contexts 1: pp 343-345**

27, 28, 30 (H6, H9, H13, H14)

• Students solve problems to show their understanding of Newton's Law of Universal Gravitation in understanding and calculating the motion of satellites.

$$F = G\frac{m_1 m_2}{d^2}$$

(14.1f; 14.2a)

• Following class discussion explain the slingshot effect in terms of the law of Conservation of Momentum and how space probes can utilise the effect.</td>
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4. Current and emerging understanding about time and space has been dependent upon earlier models of the transmission of light

29. Outline the features of the aether model for the transmission of light. **30.** Describe and evaluate the Michelson-Morley attempt to measure the relative velocity of the Earth through the aether **31.** Discuss the role of the Michelson-Morley experiments in making determinations about competing theories. **32.** Outline the nature of inertial frames of reference. **33.** Discuss the principle of relativity. **34.** Describe the	**39.** Gather and process information to interpret the results of the Michelson-Morley experiment. **40.** Perform an investigation to help distinguish between non-inertial and inertial frames of reference. **41.** Analyse and interpret some of Einstein's thought experiments involving mirrors and trains and discuss the relationship between thought and reality. **42.** Analyse information to discuss the relationship between theory and the evidence supporting it,	**<u>Resources:</u>** ▪ **Andriessen: Physics 2 – pp 79-81** ▪ **Heffernan: Physics Contexts 2 – pp 91-92** **29, 30, 31, 39 (H1, H2, H12, H14)** • Summarise notes on the Aether model for the transmission of light and draw comparisons between this model and known models of sound and water wave propagation. **(12.3d)** • Describe the: - Experimental design of the Michelson-Morley experiment - Expected results of the experiment - Actual results of the experiment - Implications for the Aether model for light transmission - Einstein's interpretation of the results **(12.1a; 14.1f)** Refer to: • http://galileo.phys.virginia.edu/classes/109N/lectures/michelson.html • Discuss how Michelson-Morley's "failed" experiment caused scientists to re-think their current accepted theory and led to the development of other theories. Refer to:	

significance of Einstein's assumption of the constancy of the speed of light. **35.** Identify that if c is constant then space and time become relative. **36.** Discuss the concept that length standards are defined in terms of time in contrast to the original metre standard. **37.** Explain qualitatively and quantitatively the consequence of special relativity in relation to: • the relativity of simultaneity • the equivalence between mass and energy • length contraction • time dilation • mass dilation **38.** Discuss the implications of mass increase, time dilation and length contraction	using Einstein's predictions based on relativity that were made many years before evidence was available to support it. **43.** Solve problems and analyse information using: $E = mc^2$ $l_v = l_0\sqrt{1-\frac{v^2}{c^2}}$ $t_v = \frac{t_0}{\sqrt{1-\frac{v^2}{c^2}}}$ $m_v = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$	http://www.hscphysics.edu.au/resource/MMAudio.mp3 • Students perform an investigation to model the Michelson-Morley experiment either by using; 1. A battery operated toy car travelling in various directions relative to wind from a fan, or, 2. A toy boat in a ripple tank or 3. A computer simulation **Resources:** ▪ **Andriessen: Physics 2 – pp 81-82** **32, 40 (H6, H12)** • Discuss how you would distinguish an inertial from a non-inertial frame of reference. • Students perform an investigation in order to clarify the distinction between an inertial and a non-inertial frame of reference either by: 1. Riding in a lift while observing a scale or spring balance with a mass on it, or 2. A computer simulation • Discuss how you would distinguish an inertial from a non-inertial frame of reference. **Resources:** ▪ **Andriessen: Physics 2 – pp 82-85**	

for space travel		**33, 34, 35, 36 (H1, H2, H6, H12)** • Outline and discuss the principle of relativity. • Listen to Einstein talking about the equivalence of energy and matter. http://www.aip.org/history/einstein/voice1.htm • Class discussion on the significance of Einstein's assumption of the constancy of light and the implications for space and time. Refer to: http://www.phys.unsw.edu.au/einsteinlight/ • Discuss how the length standard has changed as scientific understanding of measurement has developed. • Discuss why current cosmological theories employ higher dimensions. **<u>Resources:</u>** ▪ **Andriessen: Physics 2 – pp 84-94** ▪ **Butler: Macmillian Physics 2 – pp 44-52** **37, 41 (H1, H2, H6, H12, H13, H14)** • Jigsaw activity where different groups of students become experts of relativity, then share their understandings with the class: - Simultaneity - Equivalence of mass and energy - Length of contraction - Time dilation - Mass dilation	

- Examine, analyse and interpret some of Einstein's thought experiments involving mirrors and trains and discuss the relationship between thought and reality. **(12.3d; 12.4a; 13.1a; 14.1c,f,g; 14.2a)**

<u>Resources:</u>

- **Andriessen: Physics 2 – pp 84-94**
- **Butler: Macmillan Physics 2 – pp 44-52**

38, 42, 43 (H1, H2, H4, H6, H12, H14, H16)

- Identify experimental evidence confirming time dilation.
- Solve problems both qualitative and quantitative involving:

$$E = mc^2$$

$$l_v = l_0 \sqrt{1 - \frac{v^2}{c^2}}$$

$$t_v = \frac{t_0}{\sqrt{1 - \frac{v^2}{c^2}}}$$

		$$m_v = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}}$$ • Students use acquired knowledge of mass increase, time dilation and length contraction, to discuss implications on people if the technology was developed to allow humans to travel near the speed of light so that real space exploration could occur.	

Resources

Text:

- Andriessen et al (2004), **Physics 2 HSC Course (2nd Ed):** Jacaranda
- **Physics 2 HSC Course** : M. Butler: Macmillan
- **Excel HSC Physics**: Warren : Pascal
- **OTEN Handbook**: From Ideas to Implementation
- **Essential Physics**: Christian and Crossley, Book 2
- **Physics Problems for Senior Students**: Dyett, Heinemann
- **Tutorial Problems in Senior Physics**: Humphrey
- **Physics Experiments and Student Investigations**: McKittrick
- **Timesaver Worksheets on Space**

Useful Websites and Links:

- http://webs.mn.catholic.edu.au/physics/emery - Bob Emery's Physics Page
- http://www.hsc.csu.edu.au/physics/core/implementation - CSU HSC On-line
- http://www.lmpc.edu.au/default.php?KLA=Science - entry page for the OTEN science materials
- http://www.phys.unsw.edu.au/hsc/ideas.html - UNSW Physics

- http://www.science.uniserve.edu.au/school/curric/stage6/phys/ideas - Sydney University Physics
- Age - Check out your age on other planets.
- Apollo to the Moon Gallery - A great collection of facts & photos highlighting the Apollo Moon program from start to finish.
- C-Ship - Definitely worth a visit - shows the effects of Special Relativity for a traveller getting ever closer to the speed of light - excellent graphics!
- Current Space Missions - basic details of current missions to various parts of our Solar System - Voyager, Galileo, Ulysses, Cassini-Huygens and several others.
- Earth & Sky - Information on "gravity assists".
- Einstein's Mirror - A brief introduction to this thought experiment and its significance provided by NSW HSC Online.
- Galileo - The Motion of Projectiles - Excerpt from Galileo's "Two New Sciences" in which he gives his classic analysis of projectile motion
- g-forces I - effect of g-forces on pilots, along with some other interesting information on flying.
- g-forces II - another site with a basic explanation of g-forces.
- Goddard and his Rockets - information on the contribution of Robert Goddard to the development of space exploration
- Gravity Assists - An explanation of "gravity assists"
- Gravity - Questions & Answers - contains among other things a table showing times to distant places at various speeds & has links to data on spacecraft such as the Voyager
- Lectures on Galileo & Einstein - An excellent set of lectures from Michael Fowler of the University of Virginia, on the works of these two brilliant scientists.
- Lessons From The Beagle - What lessons have been learned from the loss of the Beagle 2 Mars Lander at the end of 2003? An interesting article for anyone studying the difficulties of doing Science in space.
- Mysteries of Deep Space - Classroom Activities
- Newton's Cannon - an applet demonstrating the idea. This is linked to a good lecture.
- Newton's Law of Universal Gravitation - very good notes.
- Pioneer 10 - Interesting overview of the mission of this spacecraft, which is now further from earth than any other spacecraft besides Voyager 1. Links to other missions.
- Projectile Motion - An applet - fires shots at a target - you adjust inclination, speed & value of g.
- Projectile Motion II - Another applet allowing you to experiment with the variables that determine a projectile's trajectory.
- Propulsion Systems - Current & future propulsion systems for space travel - many links (eg How the ion engine works)
- Rocket Principles - explanation of Newton's Laws & principles of rocket propulsion.
- Roller Coaster - An explanation of Roller Coaster physics.
- Roller Coaster II - A very good explanation of the physics of roller coasters & a brief definition and discussion of g-forces.
- Saturn V Rocket - details of the rocket used to launch the Apollo spacecraft.
- Slingshot Effect - further explanations
- Solar Sailing - Information on solar sail propulsion.
- Space Invaders - The transcript of a presentation on the ABC's Ockham's Razor in December 2000, discussing the dirty & lucrative sides of space exploitation.

- Space Links - Many links for this topic. Please note I have NOT checked many of these links and therefore have no idea how useful they will prove to be. Try them out & let me know if they are OK.
- Space News from Earth and Beyond - A good source of up to date news on all sorts of things to do with space.
- SEDS - Students for the Exploration and Development of Space - a wealth of information on Space, Astronomy & Rocketry. This is an excellent site with links to other very useful sites.
- The Space Place - Simple explanation of how best to use earth's orbital & rotational motion to advantage during launch.
- Space-Time - Brief description of current knowledge of the fabric of space-time
- The Way To Go In Space - Scientific American article on the future of space travel - links to other excellent articles on possible future propulsion systems.
- Time - Questions & Answers
- Weight - Determine your weight on other planets.

Videos / DVDs:

- **Physics of a Fun** – Clickview 23 minutes
- **Projectile Motion** – Clickview 23 minutes
- **The Planets** – Program 1 BBC
- **What's Special about Relativity: Einstein's Special Theory** – Clickview 32 minutes
- **Gravity Orbits & Asteroids** – Pathways to Australian Science
- **Vectors** – Clickview 19 minutes
- **Black Holes** – Quantum ABC 10/9/97
- **Galaxies** – Quantum ABC 16/10/92

Articles:

- **'Pulling Power'**; New Scientist: 28 Nov 1998 p 38-41
- '**Breaking the Heat Barrier'** New Scientist: 30 August 1997 pp 28-31
- '**On Wings of Light'** New Scientist: 10 Jan 1998 pp 34-37
- '**Striking the Solar Shock Wave'**; New Scientist: 22 March 1997 p 38-42
- **'Rocket Revolutionary'** New Scientist: 1 August 1998 pp 24-28
- **'Fantastic Voyager'** New Scientist: 4 Sept 1999 pp 26-29
- **'The Thought that Counts'**; New Scientist: 6 May 1995 p 26-31
- **'Why God Plays Dice'** New Scientist: 22 August 1998 pp 27-29
- **'On Wings of Light'** New Scientist: 10 Jan 1998 pp 34-37
- **'An End to Uncertainty'**; New Scientist: 6 March 1999 p 25-28
- **'The Legend of g'** New Scientist: 17 Jan 1998 pp 39-42

- **'The Fifth Element'** New Scientist: 3 April 1999 pp 29-32
- **'A Theory of Some Gravity'** New Scientist inside Science No 31
- **'Time Travel Machines'** Absolutely Fabulous Moments in Science ABC Publishing 1994: K. Kruszelnicki
- **'Black Holes and Centrifugal Force Paradox'**: Scientific American March 1993 pp 26-31

Glossary:

Aeronautics	Inertial frame of reference	Orbital velocity	Slingshot effect
Aether	Kepler's Law of Periods	Potential energy	Spacecraft
Astronaut	Length contraction	Projectile	Thought experiment
Centripetal force	Low Earth orbit	Range	Time dilation
Escape velocity	Mass dilation	Relativity	Trajectory
g force	Material science	Robotics	Weight
Geo-stationary orbit	Non-inertial frame of reference	Rocket	Work
Gravitational field	Orbit	Satellite	
Gravitational potential energy	Orbital decay	Simultaneity	

ASSESSMENT:

Suggested Assessment Strategies

- **Using a Pendulum to determine G:** Calculate the rate of acceleration due to gravity by investigating the gravitational effects on the oscillatory motion of an average pendulum.