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Year 10 Physics - 2016 - Term 3 | Stage 5 | Science |

Summary	Duration
This unit covers energy, forces and motion. Basically, it is split into two parts, the first addressing principles and applications of energy, the latter Newton's laws of motion and the forces which give rise to them. The two halves are linked at the end of the unit.	Sample term 10 weeks Detail: ~32 hours, across 29 class sessions

Unit overview	Enter your own title
In this Unit students use Newton's laws of motion as well as the first and second law of thermodynamics to describe and explain a variety of physical phenomena and applications derived from them. The purpose of doing so revolves around the central theme of sustainability - one of the cross-curricular priorities.	Forces and Energy for a Sustainable World

Outcomes	Assessment overview
Science K-10 › SC5-10PW applies models, theories and laws to explain situations involving energy, force and motion › SC5-11PW explains how scientific understanding about energy conservation, transfers and transformations is applied in systems › SC5-4WS develops questions or hypotheses to be investigated scientifically › SC5-5WS produces a plan to investigate identified questions, hypotheses or problems, individually and collaboratively › SC5-6WS undertakes first-hand investigations to collect valid and reliable data and information, individually and collaboratively › SC5-7WS processes, analyses and evaluates data from first-hand investigations and secondary sources to develop evidence-based arguments and conclusions › SC5-8WS applies scientific understanding and critical thinking skills to suggest possible solutions to identified problems › SC5-9WS presents science ideas and evidence for a particular purpose and to a specific audience, using appropriate scientific language, conventions and representations	The main assessment task in this unit is a first-hand investigation of a wind turbine and the parameters which affect the power which can be generated from it with the goal of maximizing that power. Students will also submit some smaller in-class investigations of power and energy in solar cells and simple mechanical systems. For the main lessons, the primary assessment will be the students' main lesson books, and time permitting, a traditional pencil and paper test.

Content	Teaching, learning and assessment	Resources
Stage 5 - Physical World PW2 The motion of objects can be described and predicted using the laws of physics. (ACSSU229) Students: a. describe qualitatively the relationship between force, mass and acceleration b. explain qualitatively the relationship between distance, speed and time c. relate acceleration qualitatively to a change in speed and/or direction as a result of a net force d. analyse qualitatively everyday situations involving motion in terms of Newton's laws PW4 Energy conservation in a system can be explained by describing energy transfers and transformations. (ACSSU190) Students: a. apply the law of conservation of energy to account for the total energy involved in energy transfers and transformations	***Assessments thus*** **ENERGY** **Week 1 - 2 middles** ▪ Mindmap of energy ▪ Introductory video on climate change (Turkana) to set context and motivation for study of renewable energies. Also include video from AYCC to help motivation to action ▪ Questions about solar panels at school. Lead to energy consumption of school vs power generated by panels. Teaching P=E/t. Give a few examples and leave question about school's situation for homework. ▪ Comparison of percentage of Australia's and Costa Rica's renewable energy usage **Week 2 - 2 middles** ▪ Continue teaching P=E/t. Give worksheet for practice. ▪ Power point of different energy types. ▪ Demonstration of hand-cranked generator.	**Week 1** ▪ Turkana Video (+ computer and display screen and speakers) ▪ Turkana Worksheet ▪ Shearwater power bill ▪ Observation of solar panel meter next to science lab ▪ World map of countries by percentage renewable energy usage ▪ Costa Rica renewable energy production. http://phys.org/news/2015-12-costa-rica-renewable-energy.html **Week 2** ▪ Power, Energy, time worksheet ▪ Hand-cranked generator ▪ Energy sources and Types, Greenhouse Effect & Sankey Diagrams worksheet **Week 3** ▪ Bouncing Balls' Energy Efficiency Worksheet

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b. describe how, in energy transfers and transformations, a variety of processes can occur so that usable energy is reduced and the system is not 100% efficient c. discuss, using examples, how the values and needs of contemporary society can influence the focus of scientific research in the area of increasing efficiency of the use of electricity by individuals and society (ACSHE228, ACSHE230) d. discuss viewpoints and choices that need to be considered in making decisions about the use of non-renewable energy resources Stage 5 - Questioning and predicting WS4 Students question and predict by: b. predicting outcomes based on observations and scientific knowledge Stage 5 - Planning investigations WS5.1 Students identify data to be collected for an investigation by:	Students list transformations between different types of energy. ▪ Teach Sankey diagrams to help reinforce conservation of energy and inefficiency of transformations. Students to do worksheet and analyse a process at home with Sankey diagram. **Week 3 - 1 middle** (1 lost to Sports Carnival) ▪ Check up on last week's homework to consolidate understanding of Sankey diagrams and the underlying principles - conservation of energy and inefficiency of energy transformations. ▪ Prepare for simple prac investigating energy principles via Bouncing Balls. ▪ Teach gravitational potential energy = E = mgh, and percentage energy efficiency = max rebound height / initial height x 100. ▪ *Class discussion*: how to test the efficiency of energy transformations for a ball? **Week 4 - 2 middles** ▪ ***Carry out bouncing ball prac*** (1st lesson) ▪ ***Collect students write up of prac*** (next lesson)	**Week 4** ▪ Bouncing Balls' Energy Efficiency Worksheet ▪ Power in Electric Circuits Worksheet **Week 5** ▪ Hand-written sheet (on Sankey diagrams - one example for Bouncing balls prac, another for a book sliding across table) ▪ Measuring Voltage, Current, Resistance Worksheet ▪ For each pair/group below: ▪ 2 multimeters ▪ 1 Testing station ▪ 1 battery ▪ Connecting wires **Week 6** ▪ ▪ For each pair/group below: ▪ 2 multimeters ▪ Solar cells

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d. justifying why variables need to be kept constant if reliable first-hand data is to be collected in controlled experiments WS5.3 Students choose equipment or resources for an investigation by: b. identifying the appropriate units to be used in collecting data Stage 5 - Conducting investigations WS6 Students conduct investigations by: a. individually and collaboratively using appropriate investigation methods, including fieldwork and laboratory experimentation, to collect reliable data (ACSIS165, ACSIS199) b. safely constructing, assembling and manipulating identified equipment c. selecting and using appropriate equipment, including digital technologies, to systematically and accurately collect and record data (ACSIS166, ACSIS200) d. using appropriate units for measuring physical quantities	▪ Lead-in with means of measuring power in circuits: $V=E_{pot}/q$ (by definition) and $I = q/t$ (by definition). Therefore $VxI= E_{pot}/q \times q/t = E_{pot}/t = P$. Thus, we measure the power consumed in a circuit device by measuring the potential difference across it and the current running through it. ▪ Prepare for student prac on measuring input power and energy captured by solar panel and transferred to light bulb, with the sight on reinforcing conclusions on energy principles - conservation and inefficiency of transformations, including via Sankey diagrams. **Week 5 - 3 middles** ▪ Start out in single middle measuring the voltage and current in circuits using multimeters. ▪ In double middle, review Sankey diagrams. I wrote up the sheet by hand (i.e. there's no digital copy) with two simple examples. ▪ End by finishing measuring voltages, currents, resistances. **Week 6 - 3 middles**	▪ 2 mirrors ▪ 1 Testing station ▪ Wires to join everything together **Week 7** ▪ For each pair/group below: ▪ 2 multimeters ▪ Wind turbine, including 3 types of blades ▪ 1 Testing station ▪ Wires to join everything together ▪ Retort stand and clamp ▪ Fan **Week 8** ▪ Masses (x3) ▪ String (x3) ▪ Retort stand ▪ Timer ▪ Video (Galilean Pendulum Clock) ▪ Video (NASA gumballs in space)

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e. reporting data and information, evidence and findings, with accuracy and honesty f. evaluating the effectiveness of the planned procedure, considering risk factors and ethical issues, and suggesting improvements as appropriate Stage 5 - Processing and analysing data and information WS7.1 Students process data and information by: a. selecting and using a variety of methods to organise data and information including diagrams, tables, models, spreadsheets and databases c. accessing data and information by using a range of appropriate digital technologies d. applying numerical procedures and mathematical concepts and using digital technologies, where appropriate WS7.2 Students analyse data and information by: b. describing relationships between variables	▪ ***Measuring voltage and current from solar cells*** ▪ Demonstration: 'Conservation of Energy and Inefficiency of Transformations in a Solar Cell' **Week 7 - 3 middles** ▪ ***MAIN ASSESSMENT WEEK!*** ▪ First middle - Pass out Assessment sheet, demonstrate the wind turbine, explain how to use it, ensure circuit is running through the bulb, answer any questions ▪ ***Double middle - Students undertake the assessment*** --- **FORCES & ENERGY** **Week 8 - 4 main lessons** **Main 1** ▪ Begin with first part of Galileo's biography ending with his observation of church candles oscillations, then move to his/our investigation of pendula ▪ Elicit factors which might influence a pendulum's period (but delay technical vocab)	▪ Rolly chair + Stack of books ▪ Paper and beaker **Week 9** ▪ Ticker-tape timer ▪ Carts ▪ Ramp ▪ Pasting board for tape ▪ Masses ▪ Long spring ▪ Tape measure ▪ Spinning top ▪ Skateboards (x2) **Week 10** ▪ Pic of Newton's Gravity Ridiculed For each group: ▪ Retort stand & Clamp ▪ Dowelling or other short stick ▪ Fishing line/string

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(ACSIS169, ACSIS203) c. assessing the validity and reliability of first-hand data e. synthesising data and information to develop evidence-based arguments f. evaluating conclusions and evidence, including identifying sources of uncertainty and possible alternative explanations (ACSIS171, ACSIS205) Stage 5 - Problem Solving WS8 Students solve problems by: d. using cause-and-effect relationships to explain ideas e. using models to explain phenomena and make predictions Stage 5 - Communicating WS9 Students communicate by: b. selecting and constructing an appropriate table, type of diagram, table or graph (histogram or sector, column or line graph) to present information and show relationships clearly and	▪ Investigate as a demonstration pendulums' periods based on three different masses, amplitude's and string lengths **Main 2** ▪ Pendulum discussion of last day's results. Conclusion - period depends only on string length. ▪ Teach technical vocab: mass, period, cycle, length and mass vs weight. ▪ Draw out the last one of mass vs. weight with interplanetary and intergalactic examples (moon, Jupiter, neutron star etc.) ▪ Due to error in measuring amplitude (see evaluation below), draw out this error and use it as a heuristic opportunity ▪ Lastly, elicit what we could use such a device for: a clock! (Watch video of simple Galilean pendulum clock) ▪ Question: who cares? What purpose could a clock serve? St.s make list of (both good and bad) uses. **Main 3** ▪ Return last days notes, highlighting feedback.	▪ Timer ▪ Video - Newton's Laws of Motion

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succinctly using digital technologies as appropriate c. using appropriate units for physical quantities and symbols to express relationships, including mathematical ones e. presenting scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations for specific audiences (ACSIS174, ACSIS208)	▪ Formalize the conclusion of the pendulum investigation $T=2\pi\sqrt{(L/g)}$ ▪ Draw out discussion of surprising results that period is independent of mass and *why* this would be so, including investigation of varying circumstances of falling pieces of paper ▪ Finish Galileo's biography, and end with class discussion of their impressions, questions, comments of this bit of history. **Main 4** ▪ Introduce free-body diagrams and vectors for explanatory purposes - no calculations ▪ Analyse pendulum both at rest and in motion with free-body diagrams ▪ Demonstrate inertia both in the case when v=0 (st.s pulling on either side of another st.; pull paper out from under a beaker at rest) and v≠0 (rolly chair with books, stopping suddenly at a desk, and show NASA video of gumballs in space). **Week 9 - 4 main lessons** **Main 5**	

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	▪ *Collect wind-turbine assessment* ▪ Discussion of last days demos: what did we see? In the case when v=0, v remained 0, in the case of v≠0, v remained (more or less) constant. ▪ Move to Newton's First Law: Inertia: Bodies at rest tend to stay at rest and bodies in motion tend to stay in motion. *Resist explanation via acceleration at this point - that'll come next* ▪ Also teach velocity vs. speed and recall vectors have both magnitude and direction. Then give examples of 1st law in a car, both speeding up, slowing down and (for reference to direction) turning a bend ▪ Begin Newton's biography **Main 6** ▪ Prime students for investigating how forces cause motion, and make reference to last day: the gumballs in space were moving, but did they have an unbalanced force on them? ▪ Run demonstration with ticker-tape timer, explaining how it works.	

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	▪ Cut tape every five dots (equal times) and focus on measuring s=d/t. Paste on board so students can see the profile of the speeds of the cart - BUT RESIST EXPLANATION UNTIL TOMORROW - let them think about what we can conclude. ▪ Run second demo with two carts attached by a spring, one with extra weight on it. Set up a measuring tape and and due a few trials to see where carts collide. Again, resist any discussion or explanation at this point. **Main 7** ▪ Discussion of last days demos. Arrive at force is directly proportional to acceleration (NOT speed). From second demo, arrive at accleration is inversely proportional to mass. Putting results together F=ma - Newton's second law. ▪ Come back to forces as vectors. Mass is not a vector but accleration *is*. Tighten up language (and concepts) from before: mass is not just moving in direction of net force, but *acclerating* in that direction. ▪ Now give example of wagon - pulling a heavy load	

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	by changing angle (direction) of force. Explain by use of free-body diagram. ▪ End with second example to ponder: In which direction is gravitational force on moon acting? In what direction is moon moving? **Main 8** ▪ As a warm-up, show st.s spinning top and ask them to list all the forces on it. Why does it slow down? Draw analogy to earth spinning and discuss its rotational inertia. ▪ Discuss question from last day regarding earth-moon system. ▪ Arrive at and teach language and concept of centripetal force/acceleration, and contrast this with moon's (tangential) velocity. Use diagrams to make this clear. ▪ Last demonstration: two st.s on skateboards at rest, one pushes the other. St.s note observations. **Week 10 - 3 mains** (1 lost to assembly) **Main 9** ▪ Discuss demo from last day - what did they see?	

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	Ask: what do you think would happen in a frictionless system (say in outer space) if someone pushed another with identical mass? ▪ Come to formalization of Newton's third law, and draw analogies in other disciplines (Le Chatelier's Principle in chem, homeostasis in bio, yin-yang in eastern philosophy etc.) ▪ Question for discussion: in light of third law, how is motion possible? Ans: remember, the forces are applied to different bodies, each of which needs to be analysed with its own free-body diagram ▪ Finish Newton's biography and with reference to controversy over Newton's new laws, show pic demonstrating its ridicule. **Main 10** ▪ Link forces and energy: W=F dot d . Use wagon again as example of work being done and how it varies with angle at which force is applied (concept and diagram only, no calculations), and (circular) planetary motion of earth-moon system where no work is done. ▪ As challenge, return to pendulum clock and get st.s	

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	to use T=2π√(L/g), rearrange to calculate what L should be for a clock (i.e. T=1s) and/or to design the clock in practice - (i.e. test with a timer the string length that produces T= 1s) **Main 11** ▪ ***Return all notes, st.s make title page and table of contents and bind main lesson books.*** Time permitting: ▪ ***Forces and Motion test*** ▪ St.s use pendulum to give one example of each of Newton's Laws ▪ Watch short video on Newton's Laws	

Enter your own title	Evaluation
Forces and Energy for a Sustainable World	**Week 1** As introductory lessons to highlight the purpose of studying physics for a sustainable society this worked well. The questions about our solar panels came from the st.s themselves. They already seem to be well aware of the climate

	change imperatives related to this concern. **Week 2** Next time round, don't cram in so much, especially in these short middle lessons. There ought to be one focussed lesson on Conservation of Energy, and a separate one on Sankey Diagrams. For each, just choose one simple example and extend it carefully so all students get it. I ended up having to go back on Sankey diagrams twice! **Week 4** Forget about deriving P=VxI - the students were just glazing over. Just give them the equation and show them how to use it with a simple example. Then give them time in class to do the same. **Week 5** For the measuring worksheet, consider leaving out resistance in future - it's not really necessary and just complicates things taking up time - for the assessment they don't really need it. The hand-written analysis of energy types by diagram worked quite well. Consider bringing in pot lid for demo - the one at home dissipates energy quite slowly - from max amplitude to rest takes several minutes. **Week 6** The demo was in the double and worked well. In future, probably best to swap these two lessons, though can't ensure you'll get a double middle before the single.

	Week 7 Double middle is *plenty* of time for st.s to collect all their data. ANON's group found substantially higher power by making the angle the blade makes with the wind shallower, though not quite perpendicular to air flow - rather unexpected and interesting! **Week 8** Delayed use of technical vocabulary: period, amplitude, mass worked well, as did especially including the story of Galileo at the beginning and describing the shift in approach to studying natural phenomena compared to the ancient Greek logico-deductive method. This story can/should be continued next day. One thing tricky was trying to get enough data to vary all three parameters, which we just managed - string length, weight, and amplitude - three for each, but it was tough fitting them all in. In future, it might be best to set a few different stations up to get the students to help speed up the process. Also, next time measure the amplitude properly using *angles not distance* (which I knew, but figured would simplify things), in the end it hindered our calculation of the pendulum's speed. **Week 9** First class seemed to work pretty well. The real crux of the concept came when asking them if the gumballs which moved (in their words) at a slow, steady pace, and in a straight line (I had to ask them about these characteristics in two parts - i.e. the direction, and the magnitude) had an unbalanced force on them. The initial response from some, including some of those who tend to be really quick about these concepts, was that, how would they move if there was no unbalanced force? It's not at all obvious that forces cause accelerations rather

	than velocities. But regardless, we arrived at the first law of inertia: objects at rest tend to stay at rest, objects in motion tend to stay in motion. We unpack forces causing acceleration in the second law.