U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

ENERGY EDUCATION AND WORKFORCE DEVELOPMENT

Energy Transfer

Grades: 9-12

Topic: Energy Basics

Owner: ACTS

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Learning Goals and Objectives

The learning goals and objectives for IB HL Physics are clearly defined by the International Baccalaureate Organization. Students that earn at least a four out of seven on three written exams and two sets of detailed lab investigations earn ten hours of college credit. As is inherent in the nature of physics, this unit overlaps many learning goals.

- 2.2 Forces and Dynamics
- 2.3 Work, Energy, and Power
- 3.1 Thermal Concepts
- 3.2 Thermal Properties of Matter
- 8.1 Energy Degradation and Power Generation
- 8.4 Non Fossil-fuel Power Production
- 10.1 Thermodynamics
- 10.2 Thermodynamic Processes

Assessment Plan

Assessment Plan Table			
Type of Assessments	IB Learning Objectives	Format of Assessment	Modifications (if needed)
Pre-Assessment	2.2, 2.3, 3.1, 3.2, 8.1, 8.4, 10.1, 10.2	15-question quiz	
Formative Assessment	2.2, 2.3, 3.1, 3.2, 10.1, 10.2	Classroom response system	
Formative Assessment	2.2, 2.3, 3.1, 3.2, 10.1, 10.2	Student concept map of patterns in energy transfer	
Post-Assessment (summative)	2.2, 2.3, 3.1, 3.2, 10.1, 10.2	45-question energy transfer quiz	

Implementation Design

Design for Instruction Table				
Instructional Activity	IB Learning Objectives	Resources	Timeframe	Assessment
A) Pre-assessment	2.2, 2.3, 3.1, 3.2, 8.1, 8.4, 10.1, 10.2		Block 1 (10 min)	pre-assessment
B) Class discussion on why energy matters	2.2, 2.3, 3.1, 3.2, 8.1, 8.4, 10.1, 10.2		Block 1 (15 min)	
C) Terminology lecture (see thermal.ppt)	2.2, 2.3, 3.1, 3.2, 10.1, 10.2		Block 1 (20 min) *Block 1 (45 min) start project in (K)*	
D) Conceptual energy transfer in a simple heating curve (see thermal.ppt)	2.2, 2.3, 3.1, 3.2, 10.1, 10.2		Block 2 (30 min)	
E) Formative Assessment using classroom response system	2.2, 2.3, 3.1, 3.2, 10.1, 10.2	purchase classroom response system	Block 2 (15 min) *Block 2 (45 min) continue project*	formative assessment
F) Terminology lecture on conservative and nonconservative forces (see energytransfer.doc)	2.2, 2.3		Block 3 (15 min)	
G) Conceptual and mathematical energy transfer in 15 simple mechanical closed systems. (see energytransfer.doc)	2.2, 2.3		Block 3 (30 min) start (G) *Block 3 (45 min) continue project* Block 4 (45 min) continue (G) *Block 4 (45 min) continue project*	
H) Student concept map of	2.2, 2.3, 3.1, 3.2, 10.1,		Block 5 (20 min)	formative

patterns in energy transfer (see EnergyTransferMap.jpg)	10.2			assessment
I) Energy Transfer Quiz (see TransferEnergyQuiz.doc)	2.2, 2.3, 3.1, 3.2, 10.1, 10.2		Block 5 (45 min)	summative assessment
J) Student concept map applying energy transfer concepts to solar photovoltaic cell.	8.1, 8.4		Block 5 (25 min)	formative assessment
K) Long-term project analyzing energy output from installed solar PV systems using online raw data sources. (see PVia.doc & PVia.xls)	8.1, 8.4	reserve computer lab for six 45-minute blocks	Block 6 (15 min) review quiz Block 6 (30 min) begin next unit *Block 6 (45 min) project* Block 7 (45 min) next unit *Block 7 (45 min) last in-class time for project*	written report

Analysis of Learning Results:
Students averaged 41% on the pre-assessment and 89% on the summative test. The clickers were not received before this unit was taught so that data could not be included.

Reflection on Teaching and Learning:
I was satisfied overall with the results on the summative evaluation. The major weaknesses were that (1) each question was not formally assigned to a specific learning objective and (2) the objectives were not reassessed at a later date for long-term mastery. I will address both weaknesses by building an ExamView database of questions that are tagged with AP/IB objectives. I am attaching six topics of ExamView questions and a syllabus demonstrating the alignment with AP/IB objectives.

Transfer of energy involving closed systems

Goals:

(1) Identify a closed system with conservative forces.

(2) Identify relationships between the following variables:

a) work from conservative forces
b) work from non-conservative forces
c) net work
d) change in kinetic energy
e) change in potential energy
f) change in internal energy
g) heat input to system or heat output from system
h) work input to system or work output from system

Definition: A conservative force (also called a restoring force) tends to pull an object back towards its equilibrium position when the object is displaced. Gravitational force, elastic force, and electric force are all conservative forces.

Definition: A closed system is one where mass is not allowed to enter or exit the system. We will consider only closed systems that only contain conservative forces within the system. *That is, non-conservative forces will be treated as external to the system.*

Definition: Change in internal energy = change in potential energy + change in kinetic energy or $\Delta U = \Delta E_p + \Delta E_k$

First Law of Thermodynamics: Change in internal energy of a closed system = heat input + work input or $\Delta U = Q + W$
(IB formula $\Delta U = Q - W$ since uses convention that work input is entered as a negative so – (-W) becomes + W for work input)

(Examples 1-15): For simplicity, the mass is always 1 kg and g is rounded to 10 m/s/s down and stays constant, which gives a force due to gravity of Fg=10 Newtons down. Any vectors indicate direction and are not drawn to scale. Also assume that no heat enters or leaves the system. Each example intentionally examines a different physical scenario.

(Ex. 1) A 1 kg object is dropped from rest and falls 1 meter *downward*. Assume free fall conditions.
Calculate the following:

a) work from conservative forces		Explain the transfer of energy in this scenario.
b) work from non-conservative forces		
c) net work		
d) change in kinetic energy		
e) change in potential energy		
f) change in internal energy		
g) work input to system		
h) work output from system		

(Ex. 2) A 1 kg object experiences a 1 m displacement *upwards* due to some initial velocity upwards. The force that generated the initial velocity has already been removed from the system.
Calculate the following:

a) work from conservative forces		Explain the transfer of energy in this scenario.
b) work from non-conservative forces		
c) net work		
d) change in kinetic energy		
e) change in potential energy		
f) change in internal energy		
g) work input to system		
h) work output from system		

(Ex. 3) An applied force of 10 N up displaces a 1 kg object 1 meter *upward*.
Calculate the following:

a) work from conservative forces		Explain the transfer of energy in this scenario.
b) work from non-conservative forces		
c) net work		
d) change in kinetic energy		
e) change in potential energy		
f) change in internal energy		
g) work input to system		
h) work output from system		

(Ex. 4) While experiencing an applied force of 10 N up, a 1 kg object is displaced 1 meter *downward*.
Calculate the following:

a) work from conservative forces		Explain the transfer of energy in this scenario.
b) work from non-conservative forces		
c) net work		
d) change in kinetic energy		
e) change in potential energy		
f) change in internal energy		
g) work input to system		
h) work output from system		

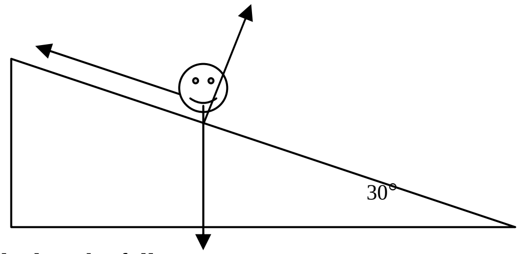
(Ex. 5) While experiencing an applied force of 12 N up, a 1 kg object is displaced 1 meter *upward*. Calculate the following:

a) work from conservative forces		Explain the transfer of energy in this scenario.
b) work from non-conservative forces		
c) net work		
d) change in kinetic energy		
e) change in potential energy		
f) change in internal energy		
g) work input to system		
h) work output from system		

(Ex. 6) While experiencing an applied force of 12 N up, a 1 kg object is displaced 1 meter *downward*. Calculate the following:

a) work from conservative forces		Explain the transfer of energy in this scenario.
b) work from non-conservative forces		
c) net work		
d) change in kinetic energy		
e) change in potential energy		
f) change in internal energy		
g) work input to system		
h) work output from system		

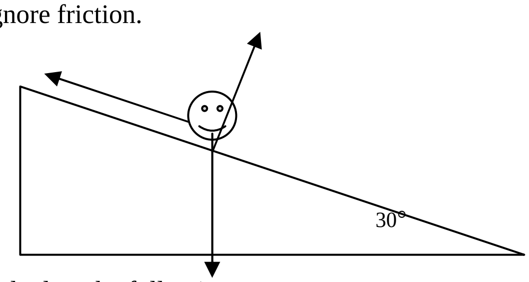
(Ex. 7) While experiencing an applied force of 5 N up a 30° incline, a 1 kg object is displaced 2 meters *upwards along the incline*. Ignore friction.



Calculate the following:

a) work from conservative forces		Explain the transfer of energy in this scenario.
b) work from non-conservative forces		
c) net work		
d) change in kinetic energy		
e) change in potential energy		
f) change in internal energy		
g) work input to system		
h) work output from system		

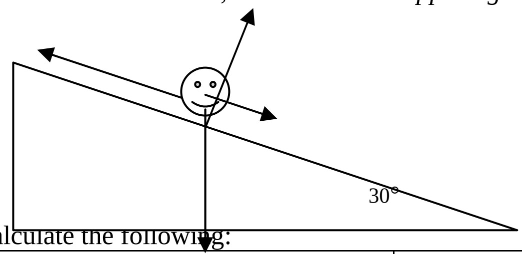
(Ex. 8) While experiencing an applied force of 7 N up a 30° incline, a 1 kg object is displaced 2 meters *upwards along the incline*. Ignore friction.



Calculate the following:

a) work from conservative forces		Explain the transfer of energy in this scenario.
b) work from non-conservative forces		
c) net work		
d) change in kinetic energy		
e) change in potential energy		
f) change in internal energy		
g) work input to system		
h) work output from system		

(Ex. 9) While experiencing an applied force of 7 N up a 30° <u>incline</u>, a 1 kg object is displaced 2 meters *upwards along the incline*. There is 1 N of friction, *in the direction opposing motion, as always*.



Calculate the following:

a) work from conservative forces		Explain the transfer of energy in this scenario.
b) work from non-conservative forces		
c) net work		
d) change in kinetic energy		
e) change in potential energy		
f) change in internal energy		
g) work input to system		
h) work output from system		

(Ex. 10) While experiencing an applied force of 10 N East, a 1 kg object on a level surface is displaced 1 meter *East*. Ignore friction.

Calculate the following:

a) work from conservative forces		Explain the transfer of energy in this scenario.
b) work from non-conservative forces		
c) net work		
d) change in kinetic energy		
e) change in potential energy		
f) change in internal energy		
g) work input to system		
h) work output from system		

(Ex. 11) While experiencing an applied force of 10 N East, a 1 kg object on a level surface is displaced 1 meter *East*. Friction is 2 N.

Calculate the following:

a) work from conservative forces		Explain the transfer of energy in this scenario.
b) work from non-conservative forces		
c) net work		
d) change in kinetic energy		
e) change in potential energy		
f) change in internal energy		
g) work input to system		
h) work output from system		

(Ex. 12) While experiencing an applied force of 10 N East, a 1 kg object on a level surface is displaced 1 meter *East*. Friction is 10 N.
Calculate the following:

a) work from conservative forces		Explain the transfer of energy in this scenario.
b) work from non-conservative forces		
c) net work		
d) change in kinetic energy		
e) change in potential energy		
f) change in internal energy		
g) work input to system		
h) work output from system		

(Ex. 13) A 1 kg object is attached to a spring (k=1 N/m) on a horizontal surface. The spring is initially at its equilibrium position. The object experiences an applied force of 1.5 N West, which causes the spring to compress 3 m West. Ignore friction.

Calculate the following:

a) work from conservative forces		Explain the transfer of energy in this scenario.
b) work from non-conservative forces		
c) net work		
d) change in kinetic energy		
e) change in potential energy		
f) change in internal energy		
g) work input to system		
h) work output from system		

(Ex. 14) A 1 kg object is attached to a spring (k=1 N/m) on a horizontal surface. The spring is initially at its equilibrium position. The object experiences an applied force of 3 N West, which causes the spring to compress 3 m West. Ignore friction.

Calculate the following:

a) work from conservative forces		Explain the transfer of energy in this scenario.
b) work from non-conservative forces		
c) net work		
d) change in kinetic energy		
e) change in potential energy		
f) change in internal energy		
g) work input to system		
h) work output from system		

(Ex. 15) A 1 kg object is attached to a spring (k=1 N/m) on a horizontal surface. The spring is initially at its equilibrium position. The object experiences an applied force of 3 N West, which causes the spring to compress 3 m West. Friction is 1 N.

Calculate the following:

a) work from conservative forces		Explain the transfer of energy in this scenario.
b) work from non-conservative forces		
c) net work		
d) change in kinetic energy		
e) change in potential energy		
f) change in internal energy		
g) work input to system		
h) work output from system		

Record the answers from the examples and use to answer the questions below.

Example #	work from conservative forces	work from nonconservative forces	net work	Δ kinetic energy	Δ potential energy	Δ internal energy	work input into system	work output from system
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								

Analysis of Relationships:

- Which work(s) always determine the change in potential energy?
- Which work(s) always determine the work input into the system?
- Which work(s) always determine the work output from the system?
- Which work(s) always determine the net work?
- Which work(s) always determine the change in kinetic energy?
- Which work(s) always determine the change in internal energy?

Analysis of Relationships: (answers)

- Which work(s) always determine the change in potential energy? the *negative* of the conservative force associated with that potential energy
- Which work(s) always determine the work input into the system? the *positive work done* by any *nonconservative* forces
- Which work(s) always determine the work output from the system? the *negative work done* by any *nonconservative* forces
- Which work(s) always determine the net work? the scalar sum of the works from *both conservative and nonconservative forces*
- Which work(s) always determine the change in kinetic energy? the net work or the scalar sum of the works from *both conservative and nonconservative forces*
- Which work(s) always determine the change in internal energy? Trick question. Only the work done by *nonconservative forces* can change the internal energy. However, although not studied here, heat added or removed can also change the internal energy of a closed system.

Summary of work done by conservative forces

- ✓ (ALWAYS) The change in potential energy is equal to the *negative* of the work done by the corresponding conservative force
- ✓ (ALWAYS) *Contribute* to the net work, which in turn can change kinetic energy
- ✓ (SOMETIMES) They can *redistribute* the internal energy between kinetic and potential.
- ✓ (SOMETIMES) They can change the internal energy by generating work output from the system.
- ✓ (ALWAYS) The path the object takes ***does not*** matter, only the endpoints.

Summary of work done by nonconservative forces

- ✓ (ALWAYS) positive work done means work input into the system
- ✓ (ALWAYS) negative work done means work output by the system
- ✓ (ALWAYS) contribute to the net work, which in turn can change kinetic energy
- ✓ (ALWAYS) the scalar sum of the work input and work output *changes* the internal energy of the system, (along with heat added or removed). The change in internal energy can be reflected by a change in potential energy, change in kinetic energy, or both.
- ✓ (ALWAYS) The path the object takes always matters.

Additional Patterns in Energy Transfer

- ✓ All *conservative forces* have a direction that results in a preferred direction to move objects. If an object is being moved in a direction that *directly opposes the preferred direction*, then it takes energy to overcome the conservative force (which always ends up increasing PE) before any energy can be spent on increasing KE. That is, when moving an object directly opposite a preferred direction, energy must first be spent on achieving constant speed before it can be spent on increasing its speed. The energy to overcome the conservative force can come from a loss in KE, work input, or heat input.
- ✓ Objects move *naturally* from high potential energy to low potential energy (always in the same *direction* as the conservative force). That is, no extra energy is required. Objects use their stored energy when moving from high PE to low PE and that energy is conserved by either transferring energy to work output, heat output or an increase in KE. By comparison, to move an object from low PE to high PE (always against the *direction* of the conservative force) requires energy from work input, heat input, or a drop in KE.
- ✓ In thermodynamics, remember that *internal energy* gets transferred *naturally* from high temperature (high average KE) to low temperature (low average KE) through the mechanism of *conduction* (colliding molecules).
- ✓ There is no pattern between the *magnitude* of the conservative force and potential energy.

Unit 1: Introduction to Science				
❖ CTHS AP/IB Learning Objective: ▪ Scaffolded to Regular Level: ➢ Scaffolded to Essential Level:	reference to AP objective	reference to IB objective	ExamView Question Numbers	Other assessments
❖ (101) Identify and distinguish between different steps of the scientific method ▪ Same ➢ Same				
❖ (102) Distinguish between independent, dependent, and control variables (by definition, equation, and graph) ▪ Same • Define independent and dependent variables				
❖ (103) Distinguish between accuracy and precision ▪ Same • Not included				
❖ (104) Read both digital and analog instruments to the right precision ▪ Same • Read scientific instruments accurately				
❖ (105) Create and properly label a data table, scatter plot, and a line-curve of best fit ▪ Same ➢ Same				
❖ (106) Identify patterns between the independent and dependent variables using the line-curve of best fit (Examples: constant, linear, linear and proportional, quadratic, inverse, exponential decay, and square root.) ▪ Same ➢ Only linear				
❖ (107) State the multipliers for the common prefixes: micro-, milli-, centi-, kilo-, mega- ▪ Same ➢ Covert metric units without dimensional analysis				
❖ (108) State the SI units for distance (m), mass (kg), time(s), temperature (K), and energy (J) ▪ Same ➢ Same				
❖ (109) Distinguish between 1-D, 2-D, and 3-D units (length, area, volume) ▪ Same ➢ Same				
❖ (110) Master unit conversions using the factor-label method (including light years, and moles) ▪ Same ➢ Not included				
❖ (111) Master notation and calculations in scientific notation and conversions to standard notation ▪ Same ➢ Not included				
❖ (112) Rearrange scientific algebraic equations using variables only. ▪ Not included. ➢ Not included				
❖ (113) Resolve two-dimensional vectors into their x-components and y-components. ▪ Not included ➢ Not included				

Unit 2: Atomic Theory and Classification of Matter				
❖ CTHS AP/IB Learning Objective: ▪ Scaffolded to Regular Level: ➢ Scaffolded to Essential Level:	reference to AP objective	reference to IB objective	ExamView Question Numbers	Other assessments
❖ (201) State that matter and energy are conserved. ▪ Same ➢ Same	III. E. 2			
❖ (202) Distinguish between physical and chemical properties ▪ Same ➢ Same	I. A I. B IV. A			
❖ (203) Distinguish between physical and chemical changes ▪ Same ➢ Same	III. A. 1 III. A. 2 III. A. 3			
❖ (204)Describe phase changes at a particle level. *Endo/exothermic nature of phase changes.* ▪ Same ➢ same	II. B. 1			
❖ (205) Distinguish between elements, compounds, and heterogeneous and homogeneous mixtures ▪ Same ➢ Distinguish between elements, compounds, and mixtures.	IV. A			
❖ (206) Distinguish between atoms and molecules. ▪ same ➢ same	IV. A	2.1		
❖ (207) Compare and contrast different models of the atom including: Democritus', Dalton's, Thomson's, Rutherford's, and Bohr's. ▪ Compare and contrast at least two different models of the atom. ➢ Same	I. A. 1			
❖ (208) Identify the patterns for subatomic particles in a typical atom including the number, location, mass, and charge of the proton, electron, and neutron. ▪ Same ➢ Same	I. A. 3 I. A. 2	2.1.1 2.1.2 2.1.5		
❖ (209) Identify the patterns for subatomic particles in ions *and isotopes.* ▪ Same ➢ Define ion *and isotope*	I. A. 3	(2.1)		
❖ (210)Distinguish between atomic number, atomic mass number, atomic mass, and molar mass: ▪ same ➢ Distinguish between atomic number, atomic mass number, and atomic mass.	I. A. 2 I.A. 3	2.1.3		
❖ (211) *Perform calculations involving atomic mass and percent abundance of naturally occurring isotopes.* ▪ Not included ➢ Not included	I. A. 2	(2.1)		

Unit 3: Electrons and the Periodic Table				
❖ CTHS AP/IB Learning Objective: ▪ Scaffolded to Regular Level: ➢ Scaffolded to Essential Level:	reference to AP objective	reference to IB objective	ExamView Question Numbers	Other assessments
❖ *(301) Describe how atomic spectral lines are created and why they are significant. Distinguish between a continuous spectrum and line spectrum.* ▪ *Relate colors produced by an excited atom to electron energy levels.* ➢ *Using the color produced by an excited atom to identify it.*	I. A. 4	2.3.2		
❖ (302) *Describe correct and incorrect aspects of the Bohr model of the atom.* ▪ Not included ➢ Not included	I. A. 1	2.3		
❖ (303) Describe how valence electrons influence chemical properties ▪ Same ➢ Define valence electrons	I.A. 5 IV. A			
❖ *(304) Describe the quantum mechanics model of the atom including written electron configurations and Aufbau diagram for the first four periods of the periodic table.* ▪ Not included ➢ Not included	1.A. 3	12.1.3 12.1.4 12.1.5 12.1.6		
❖ (305) Describe the arrangement of the periodic table into periods and groups/families ▪ Same ➢ Same	I. A. 4	3.1.2		
❖ (306) Describe similarities in chemical properties of periodic table families. Alkali metals, Alkaline Earth Metals, Halogens, and Noble Gases should be included. ▪ Same ➢ Noble Gases only.	I. A. 4	3.3.1		
❖ (307) Locate metals, transition metals, non-metals, and metalloids on the periodic table. ▪ Same ➢ Same.	I. A. 4			
❖ (308) Describe periodic trends including valence electrons, *atomic radius, first ionization energy, and electronegativity.* ▪ Valence electrons only. ➢ Not included	I. A. 4	3.2.1 3.2.2 3.2.3 3.2.4		

Unit 4: Chemical Bonding				
❖ CTHS AP/IB Learning Objective: ▪ Scaffolded to Regular Level: ➢ Scaffolded to Essential Level:	reference to AP objective	reference to IB objective	ExamView Question Numbers	Other assessments
❖ (401) Use Lewis Dot structures to indicate valence electrons. Relate valence electrons to stability. ▪ Same ➢ Same	I. B.1. a I. B.1. b I. B.1. c	4.2.3		
❖ (402) Classify and describe ionic bonding in terms of electron transfer, cations, anions, *and electronegativities.* ▪ Define ionic bonding in terms of electron transfer. ➢ Same as above	I. B.1. a I. B.1. c	4.1.1		
❖ (403) Classify and describe covalent bonding in terms of electron	I. B.1. a	4.2.1		

sharing *and electronegativity*. ▪ Classify and describe covalent bonding in terms of electron sharing ➢ Same as above	I. B.1. c	4.2.2		
❖ (404) Given the name, write the chemical formulas for ionic and covalent compounds, *and basic polyatomic ions.* ▪ Same. ➢ Write chemical formulas.	I. B.1. a III. B. 1	4.1/4.2		
❖ (405) Given the formula, write the names of ionic and covalent compounds, *and polyatomic ions.* ▪ Naming covalent compounds and ionic compounds of main group elements. ➢ Same as above	I. B.1. a III. B. 1	4.1/4.2		
❖ (406) Compare and contrast the properties of ionic and covalent compounds. ▪ Same ➢ Same	I. B.1. a I. B.1. c	4.1/4.2		

Unit 5: Chemical Reactions				
❖ CTHS AP/IB Learning Objective: ▪ Scaffolded to Regular Level: ➢ Scaffolded to Essential Level:	reference to AP objective	reference to IB objective	ExamView Question Numbers	Other assessments
❖ *(501) Identify five different types of chemical reaction: single replacement, double replacement, synthesis, decomposition, and combustion.* ▪ *Same* ➢ *Same*	III. A. 1 III. A. 2 III. A. 3			
❖ (502) Define and diagram the physical meaning of subscripts and coefficients in a chemical equation. Count the number of atoms present in a given molecule or particle. ▪ Same ➢ Count number of atoms using coefficients and subscripts.	III. B. 2	1.3.2		
❖ (503) Balance all types of chemical reactions. ▪ Same ➢ Recognize if a simple chemical reaction is balanced.	III. B. 2	1.3.2		
❖ (504) Recognize that exothermic reactions release energy and endothermic reactions absorb energy. Use an energy level diagram to determine if a reaction is endothermic or exothermic. Find the value of the activation energy from an energy level diagram. ▪ Same ➢ Recognize that exothermic reactions release energy and endothermic reactions absorb energy.	III. E			
❖ *(505) Differentiate between molecular mass & molar mass. Calculate mass of a single molecule in amu. (molecular mass). Calculate the mass of one mole of a molecule in grams (molar mass)* ▪ Same ➢ Not included.	III. B. 2 III.B. 3	1.2.1 1.2.2		
❖ *(506) Convert both ways between grams and moles* ▪ Not inlcuded ➢ Not included	III. B. 3	1.2.3		
❖ *(507) Perform mass/mole, particle/mole, and gram/molecule conversions* ▪ Not included ➢ Not included	III. B. 3	1.2.3		
❖ *(508) Calculate stoichiometric quantities in chemical reactions using mass/mole conversions.* ▪ Not included ➢ Not included	III. B. 3	1.4.1		

Unit 6: Thermodynamics – *honors level only*				
❖ CTHS AP/IB Learning Objective: ▪ Scaffolded to Regular Level: ➢ Scaffolded to Essential Level:	reference to AP objective	reference to IB objective	ExamView Question Numbers	Other assessments
❖ *(601) Define internal energy as the sum of the potential energies and kinetic energies of the particles of the substance. Internal energy of a substance may increase by absorbing heat (+Q) or inputting work. Internal energy may decrease by releasing heat (-Q) or outputting work.* ▪ *Omit* ➢ *Omit*		Physics 3.1.3		
❖ *(602) Define temperature as a quantity that is proportional to the average kinetic energy of the particles of a substance. Distinguish between temperature scales and solve temperature conversions problems.* ▪ *Omit* ➢ *Omit*		Physics 3.1.1, 3.1.2, 3.2.11, 10.1.3		
❖ *(603) Define heat as the spontaneous net transfer of energy between two substances at different temperatures by any combination of conduction, convection, and radiation. Convert between energy units of joules and calories.* ▪ *Omit* ➢ *Omit*		Physics 3.1.4		
❖ *(604) Define and solve for the specific heat capacity of a single substance. Describe the temperature change of two substances of the same mass, but with different specific heats, when they experience the same change in internal energy.* ▪ *Omit* ➢ *Omit*		Physics 3.2.1, 3.2.2		
❖ *(605) Label all parts of a heating curve. Using one calculation within a heating curve, apply either (a) Q=m*c*ΔT for changes in temperature within a phase or (b) Q=m*L for phase changes.* ▪ *Omit* ➢ *Omit*	III. E. 2	Physics 3.2.2		
❖ *(606) Using two to five calculations within a heating curve, calculate the change in internal energy of a single substance as it moves through both temperature changes and phase changes.* ▪ *Omit* ➢ *Omit*	III. E. 2	Physics 3.2.7, 3.2.8		
❖ *(607) Using a heating curve, calculate the equilibrium temperature that two substances of different temperatures will reach without a phase change occurring.* ▪ *Omit* ➢ *Omit*	III. E. 2	Scaffolding to 607		
❖ *(608) Apply conservation of energy to a heating curve. Identify when heat must be added (+Q) or removed (-Q) with proper sign conventions. Identify the direction that the particles of the substance become more structured as compared to less structured.* ▪ *Omit* ➢ *Omit*		Physics 10.2.2, 10.2.3, 10.3.1, 10.3.2		
❖ *(609) Solve Ideal Gas Law problems and the associated simplified versions, Boyle's Law and Charles' Law* ▪ *Omit* ➢ *Omit*	II. A. 1. a	Physics 10.1.1, 10.1.4		

Unit 7: Energy and Natural Resource Use				
❖ CTHS AP/IB Learning Objective: ▪ Scaffolded to Regular Level: ➢ Scaffolded to Essential Level:	reference to AP objective	reference to IB objective	ExamView Question Numbers	Other assessments
❖ (701) Identify the origin and methods of acquisition for natural resources involved in the production of everyday materials. Examples include plastics, electronics, building materials, pharmaceuticals, etc. *Categorize resources into industrial minerals, precious metals, industrial metals, petroleum products.* ▪ Same. ➢ Same.	5B, 5C, 5D, 5G			
❖ (702) Identify the origin and methods of acquisition for renewable and non-renewable energy sources. Examples include fossil fuels, natural gas, solar, geothermal, wind, nuclear, hydrologic, etc. ▪ Same. ➢ Same.	5B, 5C, 5D, 5G			
❖ (703) Identify costs, benefits, and consequences created by use, exploration, and development of renewable and non-renewable resources and energy sources. ▪ Same as above ➢ Same as above	5B, 5C, 5D, 5F, 5G			
❖ (704) Identify major natural resources that are extracted and developed in Colorado. Discuss the ecological and economic drawbacks and benefits of this. Examples include water, molybdenum, marble, gypsum, baking soda, uranium, gold, etc. ▪ Same as above ➢ Same as above	5B, 5C			
❖ (705) Discuss ways to conserve both energy and resources. ▪ Same as above ➢ Same as above	5F			

Unit 8: Meterology and Climate				
❖ CTHS AP/IB Learning Objective: ▪ Scaffolded to Regular Level: ➢ Scaffolded to Essential Level:	reference to AP objective	reference to IB objective	ExamView Question Numbers	Other assessments
❖ (801) Describe the extent and structure of the atmosphere – distinguish atmospheric layers and boundaries by temperature, pressure, and altitude. ▪ Same as AP Standard above – graphically demonstrate and include features of each layer ➢ Identify the layers of the atmosphere using a graph – *include features of each layer.*	1B			
❖ (802)Explain how the pressure gradient force, Coriolis effect, *and friction* influence local and global winds ▪ Explain how the pressure gradient force and Coriolis effect influence wind and wind belts. ➢ Explain that wind is created when molecules move from areas of high to low pressure. Describe the Coriolis effect.	1B			
❖ (803) Describe the vertical and horizontal movements of air associated with the two types of pressure centers (low and high), and generalized weather patterns associated with each. *Describe how movements of air at the surface of the earth impact air aloft* ▪ Same. ➢ Describe the vertical movements of air associated with the two types of pressure centers and generalized weather patterns associated with each	1B			
❖ (804) Classify the major air masses (continental, maritime, polar, tropical, arctic), the general weather associated with each, and the four boundaries with symbols (warm, cold, stationary, occluded fronts) created when air masses interact. *Describe the primary mid-latitude weather producing systems and how they develop* ▪ Same. ➢ Classify the major air masses and identify cold, warm, and stationary fronts.	1B			
❖ (805) Make weather predictions (temp, precip, and wind direction) for an area using data on a weather map, *upper level air,* and major wind patterns. ▪ Make predictions about temperature and wind direction for an area using data on a weather map. ➢ Make observations about current temperature and amount of precipitation using information such as present air masses and general wind patterns.	1B			
❖ (806) Differentiate between weather and climate. *Given a world map,* use the seven factors to explain the climate of a defined region (topography, wind patterns, positions of permanent high and low pressure regions, proximity to water, latitude, vegetation, ocean currents). ▪ Same. ➢ Differentiate between weather and climate.	1B			
❖ (807) Describe specific ways in which humans have modified the environment and contributed to global climate change. Discuss specific non-human sources of global climate change.	7B			

▪ Same. ➢ Same as above				

Unit 9: Earth's Structure, Planets, and Stars				
❖ CTHS AP/IB Learning Objective: ▪ Scaffolded to Regular Level: ➢ Scaffolded to Essential Level:	reference to AP objective	reference to IB objective	ExamView Question Numbers	Other assessments
❖ (901) Explain how scientists use the theory of plate tectonics, magnetism, and seismic wave properties to develop models of the Earth's interior. ▪ Explain how scientists use the theories of magnetism and seismic wave properties to develop models of the Earth's interior. ➢ Explain how scientists use seismic wave properties to develop models of the Earth's interior.	1A			
❖ (902) Distinguish between the layers of the Earth and describe the physical *and chemical* properties of each layer. ▪ Same. ➢ Given a diagram of the Earth, label the layers and describe the physical properties of each layer.	1A			
❖ (903) Use the force of universal gravitation to explain why celestial bodies remain in orbit and why masses are attracted to each other in space. *The force is directly proportional to the two masses and inversely proportional to the square of the distance between the masses.* ▪ Same. ➢ Same.				
❖ (904) Calculate scaled sizes of celestial bodies and distances between them. ▪ Same. ➢ Use given scaled sizes to construct a model of celestial bodies and the distances between them.				
❖ (905) List and describe types of electromagnetic radiation emitted from stars. Discuss how bright and dark line emission spectra help to determine chemical compositions of stars. ▪ Same. ➢ Same.				
❖ (906) Classify stars based on mass, color, temperature, age, and *spectral class (O, B, A, F, G, K, M).* ▪ Classify stars based on mass, color, temperature, and age. ➢ Classify stars based on mass, color, temperature, and age.				
❖ (907) State *and explain* the life cycle of a star. Distinguish between the death of a low mass versus a high mass star. ▪ Same. ➢ Same.				

Unit 10: Linear Motion (Kinematics)				
❖ CTHS AP/IB Learning Objective: ▪ Scaffolded to Regular Level: ➢ Scaffolded to Essential Level:	reference to AP objective	reference to IB objective	ExamView Question Numbers	Other assessments
❖ (1001) Distinguish between vector and scalar quantities, and give examples of each. ▪ Same	I.A.1.a	1.3.1		

➢ Same				
❖ (1002) Determine the sum or difference of two vectors by graphical or numeric method. (0,° 90°, 180°) ▪ Omit 90° ➢ Omit 90°	I.A.1.a	1.3.2		
❖ (1003) Resolve vectors into perpendicular components along chosen axes. ▪ Omit ➢ Omit	I.A.1.a	1.3.3		
❖ (1004) Define distance, displacement, speed, velocity, and acceleration. ▪ Same ➢ Same	I.A.1.b	2.1.1		
❖ (1005) Explain the difference between instantaneous and average values of speed, velocity, and acceleration. ▪ Same ➢ Same	I.A.1.a	2.1.2		
❖ (1006) Solve problems involving uniform acceleration for both the horizontal and vertical (free fall) direction. ▪ Solve problems involving uniform acceleration for *both* the horizontal *and vertical (free fall)* direction. ➢ Same	I.A.1.b	2.1.4- 2.1.5		
❖ (1007) Draw and analyze distance-time graphs, displacement-time graphs, velocity-time graphs, and acceleration-time graphs. ▪ Same ➢ Same	I.A.1.a	2.1.7		
❖ (1008) Calculate slopes of displacement-time graphs and velocity-time graphs. Calculate the areas under velocity-time and acceleration-time graphs. ▪ Omit ➢ Omit	I.A.1.a	2.1.8		

Unit 11: Forces (Dynamics)				
❖ CTHS AP/IB Learning Objective: ▪ Scaffolded to Regular Level: ➢ Scaffolded to Essential Level:	Reference to AP objective	Reference to IB objective	ExamView Question Numbers	Other assessments
❖ (1101) Calculate the weight of a body using the expression W=mg ▪ Same ➢ Same	I.B.2.b	2.2.1		
❖ (1102) Identify the forces acting on an object and draw free-body diagrams representing the forces acting. ▪ Same ➢ Same	I.B.2.a	2.2.2		
❖ (1103) Calculate the net force in different situations. ▪ Same ➢ Same	I.B.2.b	2.2.3		
❖ (1104) State Newton's First Law of Motion and describe examples (Fnet=0) ▪ Same ➢ Same	I.B.2.a	2.2.4-2.2.5		
❖ (1105) State the condition for translational (static) equilibrium and solve corresponding problems. ▪ *State the condition for translational (static) equilibrium and solve corresponding problems*. ➢ Omit	I.B.2.a	2.2.6-2.2.7		
❖ (1106) State Newton's Second Law of Motion (Fnet=ma) and solve corresponding problems. ▪ Same ➢ Same	I.B.2.b	2.8-2.9		
❖ (1107) State Newton's Third Law of Motion and solve corresponding problems. ▪ State the law only. ➢ State the law only.	I.B.3.a	2.2.14-2.2.15		
❖ (1108) Solve problems with two-dimensional forces applied to Newton's Second Law. ▪ Omit ➢ Omit	I.B.2.b	n/a		
❖ (1109) State Newton's Law of Universal Gravitation and solve corresponding problems. ▪ Omit ➢ Omit	I.f.4	6.1.1 and 6.1.5		

Unit 12: Momentum				
❖ CTHS AP/IB Learning Objective: ▪ Scaffolded to Regular Level: ➢ Scaffolded to Essential Level:	reference to AP objective	reference to IB objective	ExamView Question Numbers	Other assessments
❖ (1201) Define linear momentum and impulse. ▪ Same. ➢ Same	I.D.2	2.2.10		
❖ (1202) State the law of conservation of momentum and solve corresponding problems involving lumping (inelastic collisions) and non-lumping (elastic collisions) ▪ State the law of conservation of momentum and calculate the momentum of an individual object. ➢ State the law only.	I.D.3.a	2.2.12 and 2.3.8		
❖ (1203) Solve problems involving impulse [$F\Delta t=\Delta(mv)$] ▪ Omit ➢ Omit	I.D.2	2.2.13		

Unit 13: Energy				
❖ CTHS AP/IB Learning Objective: ▪ Scaffolded to Regular Level: ➢ Scaffolded to Essential Level:	Reference to AP objective	Reference to IB objective	ExamView Question Numbers	Other assessments
❖ (1301) Define energy, work, heat, and temperature. Differentiate between heat and temperature. ▪ Same ➢ Same	I.C.1	2.3.1, 3.1.4		
❖ (1302) State the three methods of heat transfer (conduction, convection, radiation). ▪ Same ➢ Same	I.C.1	3.1		
❖ (1303) Define kinetic energy, <u>change</u> in gravitational potential energy, and <u>change</u> in elastic potential energy. ▪ Same ➢ Same but omit change in elastic potential energy	I.C.1.b, I.C.2.b	2.3.4, 2.3.5		
❖ (1304) *Solve problems using the work done by a force [W=F*d*cos(theta)] Include positive work, negative work, and zero work.* ▪ Omit ➢ Omit	I.C.1.a	2.3.3		
❖ (1305) Define internal energy as the sum of all the potential energies and kinetic energies of all the molecules of an object. ▪ Same ➢ Omit	I.C.3.b	3.1.3		
❖ (1306) Compare and contrast closed systems and open systems. ▪ Same ➢ Same	II.C.2.a	10.2.2		
❖ (1307) State the principle of conservation of energy in terms of the first law of thermodynamics for a closed system. $\Delta U=Q+W$. Total Mechanical Energy (TME) is the special case of a closed system when Q=0 and W=0. That is, TME means $\Delta KE + \Delta PE = 0$. ▪ TME only ➢ Omit	II.B.1, II.C.2	2.3.6 and 10.2.2, 10.2.3		
❖ (1308) Solve problems using conservation of energy. ▪ TME only ➢ TME only, omit change in elastic potential energy	I.C.3	2.3.11		
❖ (1309) *Define power and solve corresponding problems.* ▪ *Same* ➢ *Same*	I.C.4	2.3.9, 2.3.11		

Unit 14: Simple Harmonic Motion (SHM) and Waves				
❖ CTHS AP/IB Learning Objective: ▪ Scaffolded to Regular Level: ➢ Scaffolded to Essential Level:	reference to AP objective	reference to IB objective	ExamView Question Numbers	Other assessments
❖ *(1401) Define oscillations, displacement, amplitude, frequency, period, and phase difference.* ▪ *Same* ➢ *Omit*	I.F.1	4.1.1 and 4.1.2		
❖ *(1402) Sketch a graph of displacement as a function of time of simple harmonic motion (ex. horizontal spring-mass system). Identify amplitude, period, and frequency from the graph.* ▪ *Same* ➢ *Omit*	I.F.1.a	4.1.6		
❖ *(1403) State how the total energy of SHM depends on the square of the amplitude. Identify in a graph of SHM how the potential energy and kinetic energy vary as a function of time.* ▪ *Same* ➢ *Omit*	I.F.1.g	4.2.1		
❖ *(1404) Distinguish between SHM, traveling (progressive) wave, and a wave pulse. Traveling waves are repeating waves that continue to move outward from the source and transfer energy over large distances. SHM the motion is confined to a local spatial region. A pulse is a single non-repeating traveling wave.* ▪ *Same* ➢ *Omit*	IV.A.1	4.4.1, 4.4.2		
❖ (1405) For a traveling wave, identify wavelength, wave speed, {overlaps with SHM: displacement, amplitude, frequency, and period}. ▪ Same ➢ Same	IV.A.1.b	4.4.6		
❖ (1406) Define crest, trough, rarefaction, and compression. Describe and give examples of transverse and longitudinal waves. ▪ Same ➢ Same	IV.A.1.a	4.4.3, 4.4.5		
❖ (1407) Draw and explain displacement-time graphs and displacement-position graphs for transverse and longitudinal waves. ▪ Same ➢ Same	IV.A.2.a	4.4.7		
❖ (1408) Solve problems using the relationship between wave speed, wavelength, and frequency (v=wavelength*f). ▪ Same ➢ Omit	IV.A.1.b	4.4.8		
❖ (1409) Distinguish between mechanical and electromagnetic waves. State that EM waves travel at the speed of light in a vacuum. ▪ Same ➢ Replace terminology with light (EM) and sound (mechanical)	IV.B.2	4.4.9, G1		
❖ (1410) State and apply the principle of superposition via constructive and destructive interference. ▪ *Same* ➢ *Same*	IV.A.4	4.5.5, 4.5.6, 4.5.7		
❖ (1411) Describe wave properties as they enter a new medium; reflection, refraction, and diffraction. Solve refraction problems using Snell's law. State wave frequency stays constant across a boundary. ▪ Omit Snell's law ➢ Omit	IV.B.1	4.5.1, 4.5.2, 4.5.4		
❖ (1412) Describe the Doppler Effect for a wave source (1) moving towards a stationary observer and (2) away from a stationary observer.	IV.A.1.c	11.2.1, 11.2.2		

▪ *Same* ➢ *Same*				

Unit 15: Electrostatic Force and DC Circuits				
❖ CTHS AP/IB Learning Objective: ▪ Scaffolded to Regular Level: ➢ Scaffolded to Essential Level:	reference to AP objective	reference to IB objective	ExamView Question Numbers	Other assessments
❖ *(1501) State and solve problems using Coulomb's Law, including the direction of the force and the definition of charge.* ▪ *Same* ➢ *Omit*	III.A.1.a, and III.A.1.b	6.2.4, 6.2.8		
❖ *(1502) Define voltage (potential difference), current, resistance, and power including symbols and units.* ▪ *Same* ➢ *V, I, R only*	III.C.1	5.1.1, 5.1.5, 5.1.6, 5.1.10		
❖ *(1503) Define and solve problems using Ohm's Law.* ▪ *Same* ➢ *Same*	III.C.1	5.1.8, 5.1.11		
❖ *(1504) Solve problems involving power.* ▪ *Same* ➢ *Omit*	III.C.1	5.1.10		
❖ *(1505) Define and draw circuits with circuit symbols including battery, resistors, switches and wires.* ▪ *Same* ➢ *Same*	III.C.2.a	5.2.4		
❖ *(1506) Describe the properties and proper use of ammeters and voltmeters.* ▪ *Use only* ➢ *Use only*	III.C.2.d	5.2.5		
❖ *(1507) Identify, draw, and state properties of a series circuit (voltage divider) and a parallel circuit (current divider), including calculating total resistance and battery current.* ▪ *Same* ➢ *Omit*	III.C.2.a	5.2.3, 5.2.6		
❖ *(1508) Solve for current, voltage, or resistance for a mixed circuit containing combinations of series and parallel resistors.* ▪ *Omit* ➢ *Omit*	III.C.2.a	5.2.8		

Name: ______________________________ Solar PV Internal Assessment Period: _______

This assessment counts for two quiz grades and 4.5 hours towards the required 60 hours of internal assessment.

Goals:

(1) Evaluate the daily and monthly energy collected from installed PV systems using data from online databases
(2) Evaluate the monthly capacity factor of installed PV systems
(3) Calculate the electric grid dollars of the solar energy collected monthly
(4) Calculate the gasoline equivalent of the solar energy collected monthly
(5) Calculate the "electric gasoline" equivalent of the solar energy collected monthly

Part I: Analyzing PV Data

1) Go to www.soltrex.com Click on Utah and then Zion National Park. For the two years 2006 and 2007, enter the actual energy created each month (in kWh) into a spreadsheet. *Without asking the teacher*, think of an efficient way to set up the spreadsheet. There will be many calculations on the monthly energy data and at least one plot with months as the independent variable. There will also be future PV locations that require the same analysis. Use units in the headings and gridlines throughout the spreadsheet.
2) Calculate the average solar energy collected for every month (12 averages).
3) Convert the *monthly average energy* to a *daily average energy for the month* using the exact number of days in each particular month. (12 averages)
4) Using the *daily* energy averages for each month, calculate the equivalent number of *daily* hours that the PV system would have to collect energy at its *maximum power rating* to generate the same amount of *daily* energy. (12 averages)
5) For each *month*, calculate the *maximum theoretical energy* (in kWh) that the system could generate if it ran at maximum power for 24 hours for the entire month. (12 calculations)
6) Capacity factor is a ratio of how much energy is actually produced compared to its maximum theoretical energy production. Calculate the capacity factor for each month.
7) Plot and label capacity factor vs. month.

[A few answers for the Utah installation: (3) Feb. 30.34 kWh, (4) Dec. 1.76 hours (5) June 7660.80 kWh (6) August 14.76%]

Part II: Inputting the Electricity into the Electrical Grid

8) Find the state average electricity price for residential customers for the location in 2006 and express in $/kWh (also provide web address).
9) Using the state's electricity rate, calculate how many dollars of energy the PV system is generating each month (12 calculations). Many states have passed laws requiring utility companies to implement net metering. *Net metering* requires that the utility company *credit* customers for electricity input into the electric grid at the same rate that they charge customers for electricity used out of the electric grid. In Colorado, it is state law that utilities must pay the customer at the retail rate for excess energy generated.

Part III: Using the Electricity to Supply an Electric Car

10) It is also possible to charge a *lithium ion car battery* from energy captured in the solar panels to substitute for gasoline. However, the energy conversion is not 100% efficient. Find out how efficiently lithium ion batteries store and release electricity (also provide web address).
11) For each month, calculate how much energy could be stored in lithium ion batteries.
12) Find (and provide web address) the amount of energy in 1 gallon of *gasoline* expressed in kWh.
13) Calculate the equivalent number of gallons of gasoline that each location is generating each month. (12 calculations) For this calculation only, assume that electric engines and gasoline engines have the same efficiencies.
14) Find the efficiency of an electric engine and the efficiency of a gasoline engine (and include web address).
15) Calculate the ratio: (Δenergy output) /(energy input) = (higher efficiency electric engine – lower efficiency gasoline engine)
16) Since electric engines are more efficient, use the above ratio to calculate the gallons of "electric gasoline" generated each month.
17) Using $4/gallon, calculate how many dollars of "electric gasoline" the PV system is generating each month (12 calculations)
18) For each month, calculate the ratio of "electric gasoline dollars" to "grid dollars ".

<u>Part IV: Generate and evaluate five research questions as assigned by teacher.</u>
<u>Independent or control variables</u>: manufacturer of solar panels, year of installation, location of installation, size of installation

*Each student will be assigned **one** independent variable and will **control** the other three possible independent variables for five <u>additional</u> installations from soltrex.com (5 variations of the independent variable). The **entire** spreadsheet must be completed for each installation examined. However, only the five dependent variables below must be examined as research questions. That is, each student must generate and evaluate **five** research questions. It is not significant that there are five dependent variables and five installations required.*

<u>*Dependent variables*</u>: (1) average monthly energy, (2) maximum theoretical monthly energy, (3) monthly capacity factor, (4) monthly grid dollars, (5) monthly "electric-gasoline" dollars

<u>Sample Research Question</u>: Does the manufacturer of the solar panels affect the average monthly energy generated by the solar panels?

Grading Rubric

Parts I - III combined will count for one quiz grade. Each item on the checklist will count 4 points each with *no partial credit*. Part IV will count as a separate quiz grade.

Part I: (put in spreadsheet)
___ Spreadsheet contains all gridlines, all headings, and all units
___ two years of energy data for each month
___ average energy for each month
___ daily average energy for each month
___ monthly theoretical energy
___ monthly capacity factor
___ labeled plot of monthly capacity factor

Part II: (continue same spreadsheet)
___ 2006 state electricity cost & website
___ monthly grid dollars

Part III: (continue same spreadsheet)
___ lithium ion efficiency & website
___ monthly battery storage
___ energy in one gallon of gasoline & website
___ monthly gallons of gas
___ both electric and gas engine efficiencies and websites
___ efficiency ratio
___ equivalent monthly gallons of "electric gasoline"
___ monthly "electric gasoline" dollars
___ monthly ratio of dollars
___ Subjective overall organization and neatness of work (10 or 12 point font, spreadsheet neatly taped, graph on single page, sections clearly labeled, etc.). I am not looking for decoration, just efficient and clear communication of information.

Part IV: (Sharing of data among students is not allowed!)
___ In 2-3 sentences, justify how the five locations selected satisfy your independent and control variables. (10 points)
___ Complete the entire spreadsheet for all 5 installations (15 points)

Each research question will count 15 points total. Each checklist item within each research question counts 3 points with <u>no partial credit</u>. For EACH of the FIVE research questions:
___ State research question
___ List independent, dependent, and control variables
___ Label, graph, and curve-fit the appropriate data
___ Concisely answer the research question by referencing the trend in the data. Two sentences should be sufficient.
___ Subjective overall organization and neatness of work (10 or 12 point font, spreadsheet neatly taped, graph on single page, sections clearly labeled, etc.). I am not looking for decoration, just efficient and clear communication of information.

Timeline:
There will be six 45-minute segments of computer lab time allocated to this assessment. About 2.5 segments for parts I-III and about 3.5 segments for part IV. Complete the table below with the information provided by the teacher.

Segment #	Date	Computer Lab	Estimated Pace
1			Part I
2			Part II and most of Part III
3			Finish Part III and Start Part IV
Final Due Date Parts I-III		n/a	Due ***during the first 5 minutes*** of the class period exactly ***four*** class periods after segment 3. -20 points per class period late. Students not present in class, for whatever reason, still have the same deadline --- email if necessary, but I eventually require a hard copy. I highly encourage early submission.
4			Part IV
5			Part IV
6			Part IV
Final Due Date Part IV		n/a	Due ***during the first 5 minutes*** of the class period exactly ***four*** class periods after segment 6. -20 points per class period late. Students not present in class, for whatever reason, still have the same deadline --- email if necessary, but I eventually require a hard copy. I highly encourage early submission.

Used www.shec-labs.com/calc/fuel_energy_equivalence.php to find energy content in 1 gallon of gasoline expressed in kWh. (36.718 kWh)

I've seen 99.9% efficiency for lithium ion battery on wikipedia.
Project Better Place claims electric motors are over 90% efficient. Wiki claims internal combustion averages 20% with theoretical maximum at 37%

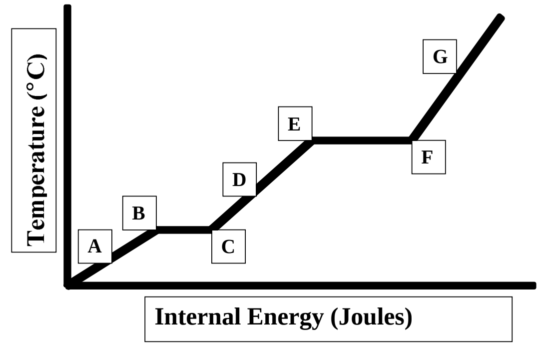
Find 3 Unique Data Locations: (consider having them complete 1 location (that I have the answers to check) for all steps and then do 2 other unique locations)

Find monthly measured PV data (not predicted) for at least 24 consecutive months from *three different time zones.* Each student must have a unique set of data, verified by the teacher. To speed up teacher approval, it is advisable to have two or three from each time zone in case another student is using one of your locations.

Location #	Time zone	City & State	Maximum Power Rating of the installed system (power usually in kW)	Number of consecutive months of solar energy data (energy usually in kWh)
1				
2				
3				
4				
5				
6				
7				
8				
9				

For each location:

**** NO CALCULATOR OR FORMULA SHEET *** SIN(30°)=0.5
Name: ___________________________________ Transfer of Energy Quiz Period:_____
(1-12) For the following questions, assume a closed system and refer to the graph below. Assume no input work and no output work. Further assumptions will be question-specific.



1. Which of the following shows the changes, if any, in the potential energy and in the kinetic energy of the molecules of a liquid as it *vaporizes*? Assume heat input but no heat output.
(a) PE decreases, KE increases (b) PE increases, KE constant
(c) PE constant, KE decreases (d) PE decreases, KE constant

2. Which of the following shows the changes, if any, in the potential energy and in the kinetic energy of the molecules of a liquid as it *freezes*? Assume heat output but no heat input.
(a) PE decreases, KE increases (b) PE increases, KE constant
(c) PE constant, KE decreases (d) PE decreases, KE constant

3. Assume *heat is input* and no heat is output during <u>section A</u> of the graph.
Either pick all true **<u>or</u>** select which statement is <u>false</u> from b->d.
(a) Statements b->d are all true. (b) the internal energy is increasing
(c) the potential energy is increasing (d) the kinetic energy is increasing

4. Assume *heat is output* and no heat is input during <u>section A</u> of the graph.
Either pick all true **<u>or</u>** select which statement is <u>false</u> from b->d.
(a) Statements b->d are all true. (b) the internal energy is decreasing
(c) the potential energy is decreasing (d) the kinetic energy is decreasing

5. Assume *heat is input* and no heat is output during <u>section B-C</u> of the graph.
Either pick all true **<u>or</u>** select which statement is <u>false</u> from b->d.
(a) Statements b->d are all true. (b) the internal energy is increasing
(c) the potential energy is increasing (d) the kinetic energy is increasing

6. Assume *heat is output* and no heat is input during <u>section B-C</u> of the graph.
Either pick all true **<u>or</u>** select which statement is <u>false</u> from b->d.
(a) Statements b->d are all true. (b) the internal energy is decreasing
(c) the potential energy is decreasing (d) the kinetic energy is decreasing

7. Assume *heat is input* and no heat is output during <u>section D</u> of the graph.
Either pick all true **<u>or</u>** select which statement is <u>false</u> from b->d.
(a) Statements b->d are all true. (b) the internal energy is increasing
(c) the potential energy is increasing (d) the kinetic energy is increasing

8. Assume *heat is output* and no heat is input during <u>section D</u> of the graph.
Either pick all true **<u>or</u>** select which statement is <u>false</u> from b->d.
(a) Statements b->d are all true. (b) the internal energy is decreasing
(c) the potential energy is decreasing (d) the kinetic energy is decreasing

9. Assume *heat is input* and no heat is output during <u>section E-F</u> of the graph.
Either pick all true **<u>or</u>** select which statement is <u>false</u> from b->d.
(a) Statements b->d are all true. (b) the internal energy is increasing
(c) the potential energy is increasing (d) the kinetic energy is increasing

10. Assume *heat is output* and no heat is input during <u>section E-F</u> of the graph.
Either pick all true **<u>or</u>** select which statement is <u>false</u> from b->d.
(a) Statements b->d are all true. (b) the internal energy is decreasing
(c) the potential energy is decreasing (d) the kinetic energy is decreasing

11. Assume *heat is input* and no heat is output during <u>section G</u> of the graph.
Either pick all true **<u>or</u>** select which statement is <u>false</u> from b->d.
(a) Statements b->d are all true. (b) the internal energy is increasing
(c) the potential energy is increasing (d) the kinetic energy is increasing

12. Assume *heat is output* and no heat is input during section G of the graph.
Either pick all true **or** select which statement is false from b->d.

(a) Statements b->d are all true. (b) the internal energy is decreasing
(c) the potential energy is decreasing (d) the kinetic energy is decreasing

13. Assume heat is input and no heat is output. If a gas behaves like an *ideal gas*, what approximation is made?
(a) its KE can be ignored (b) its PE can be ignored (c) its change in internal energy can be ignored

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(14-18) For the following questions, assume a closed system.

14. If 100 Joules of work is done on the system and 100 Joules of heat is added to the system, the change in the internal energy of the system will be (a) 0 (b) 200 J (c) 100 J (d) -100 J (e) -200 J

15. If 100 Joules of work is done on the system and 100 Joules of heat is output from the system, the change in the internal energy of the system will be (a) 0 (b) 200 J (c) 100 J (d) -100 J (e) -200 J

16. If 100 Joules of work is done by the system and 100 Joules of heat is input to the system, the change in the internal energy of the system will be (a) 0 (b) 200 J (c) 100 J (d) -100 J (e) -200 J

17. If 100 Joules of work is done by the system and 100 Joules of heat leaves the system, the change in the internal energy of the system will be (a) 0 (b) 200 J (c) 100 J (d) -100 J (e) -200 J

18. If 400 Joules of work is done by the system, 200 J of work is done on the system, 200 J of heat is added to the system, and 100 Joules of heat leaves the system, the change in the internal energy of the system will be
(a) 0 (b) 200 J (c) 100 J (d) -100 J (e) -200 J

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19. Two objects X and Y are made of the same material and are at the same temperature. Object X is more massive. Compare their average KE and their total energy of their molecules respectively.
(a) same, greater in X (b) same, less in X (c) greater in X, same (d) less in X, same

20. The internal energy of a liquid substance is equal to
(a) average KE of the molecules (b) total KE of the molecules
(c) total PE of the molecules (d) total PE & KE of the molecules

21. For an ideal gas, the temperature is linearly proportional to
(a) average KE of the molecules (b) total KE of the molecules
(c) total PE of the molecules (d) total PE & KE of the molecules

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(22-29). While experiencing an applied force of 10.0 N upward, a 1.00 kg object is displaced 3.00 meter *downward*. Use g=10.0 m/s/s down. Assume that no heat enters or leaves the system.

22. Calculate the work (in J) from the conservative forces.
(a) -40 (b) -30 (c) 0 (d) 30 (e) 40

23. Calculate the work (in J) from the non-conservative forces.
(a) -40 (b) -30 (c) 0 (d) 30 (e) 40

24. Calculate the net work (in J).
(a) -40 (b) -30 (c) 0 (d) 30 (e) 40

25. Calculate the change in kinetic energy (in J).
(a) -40 (b) -30 (c) 0 (d) 30 (e) 40

26. Calculate the change in potential energy (in J).
(a) -40 (b) -30 (c) 0 (d) 30 (e) 40

27. Calculate the change in internal energy (in J).
(a) -40 (b) -30 (c) 0 (d) 30 (e) 40

28. Calculate the work input to system (in J).
(a) 0 (b) 10 (c) 20 (d) 30 (e) 40

29. Calculate the work output from system (in J).
(a) 0 (b) -10 (c) -20 (d) -30 (e) -40

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(30-37). While experiencing an applied force of 10.0 N up a 30.0° incline, a 1.00 kg object is displaced 4.00 meters *upwards along the incline*. Ignore friction. Use g=10.0 m/s/s down. Assume that no heat enters or leaves the system.

30. Calculate the work (in J) from the conservative forces.
(a) -40 (b) -20 (c) 0 (d) 20 (e) 40

31. Calculate the work (in J) from the non-conservative forces.
(a) -40 (b) -20 (c) 0 (d) 20 (e) 40

32. Calculate the net work (in J).
(a) -40 (b) -20 (c) 0 (d) 20 (e) 40

33. Calculate the change in kinetic energy (in J).
(a) -40 (b) -20 (c) 0 (d) 20 (e) 40

34. Calculate the change in potential energy (in J).
(a) -40 (b) -20 (c) 0 (d) 20 (e) 40

35. Calculate the change in internal energy (in J).
(a) -40 (b) -20 (c) 0 (d) 20 (e) 40

36. Calculate the work input to system (in J).
(a) -40 (b) -20 (c) 0 (d) 20 (e) 40

37. Calculate the work output from system (in J).
(a) -40 (b) -20 (c) 0 (d) 20 (e) 40

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(38-45). A 1.00 kg object is attached to a spring (k=4.00 N/m) on a horizontal surface. The spring is initially at its equilibrium position. The object experiences an applied force of 24.0 N West, which causes the spring to compress 3.00 m West. Friction is 4.00 N. Use g=10.0 m/s/s down. Assume that no heat enters or leaves the system.

38. Calculate the work (in J) from the conservative forces.
(a) -36 (b) 36 (c) -18 (d) 18 (e) 0

39. Calculate the work (in J) from the non-conservative forces.
(a) -60 (b) 60 (c) -72 (d) 70 (e) 42

40. Calculate the net work (in J).
(a) -60 (b) 60 (c) -72 (d) 70 (e) 42

41. Calculate the change in kinetic energy (in J).
(a) -60 (b) 60 (c) -72 (d) 70 (e) 42

42. Calculate the change in potential energy (in J).
(a) -36 (b) 36 (c) -18 (d) 18 (e) 0

43. Calculate the change in internal energy (in J).
(a) -60 (b) 60 (c) -72 (d) 70 (e) 42

44. Calculate the work input to system (in J).
(a) 72 (b) 12 (c) 0 (d) 18 (e) 36

45. Calculate the work output from system (in J).
(a) -72 (b) -12 (c) -60 (d) -18 (e) -36