(1H.L1.1) Familiarize Stage

Thursday, March 29, 2018 8:34 PM

1st Law and Heat (1H)

Familiarize Stage:

Pre-lecture 1: 1st Law of Thermodynamics, Energy Transfers

Reading

1. Read

Lecture Videos

1. Watch

Example Problems

1. Watch

Simulations

1. Sim

Other Suggested Content

1. Check out

Practice

1. Try

Homework

1H.L1.1-01

Description: What is heat?

Learning Objectives: [x,xx,...] Put the learning objective numbers here

Problem Statement: We learned that work is a mechanism to change the energy of a system. What is heat?

(1) A measure of internal energy in a system
(2) A measure external energy outside a system
(3) A second mechanism to change the energy of a system
(4) A measurement of the temperature of a system
(5) A measure of the average kinetic energy of a system

Answer: (3)

1H.L1.1-02

Description: understanding heat transfer

Learning Objectives: [x,xx,…] Put the learning objective numbers here

Problem Statement: What is the connection between heat and temperature?

(1) They are the same thing.
(2) Heat is work done on a hot object.
(3) Heat is energy transferred at a constant temperature.
(4) Heat is energy transfer due to a temperature difference.

Answer: (4)

1H.L1.1-03

Description: Direction of heat transfer

Learning Objectives: [x,xx,...] Put the learning objective numbers here

Problem Statement: When two bodies of different temperatures are in contact, what is the overall direction of heat transfer?

(1) The overall direction of heat transfer is from the higher-temperature object to the lower-temperature object.
(2) The overall direction of heat transfer is from the lower-temperature object to the higher-temperature object.
(3) The direction of heat transfer is first from the lower-temperature object to the higher-temperature object, then back again to the lower-temperature object, and so-forth, until the objects are in thermal equilibrium.
(4) The direction of heat transfer is first from the higher-temperature object to the lower-temperature object, then back again to the higher-temperature object, and so-forth, until the objects are in thermal equilibrium.

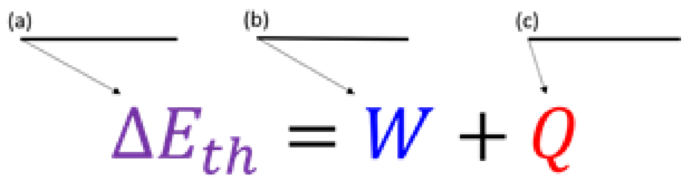
Answer: (1)

1H.L1.1-04

Description: Infographic quiz first law of thermodynamics - label matching

Learning Objectives: [x,xx,...] Put the learning objective numbers here

Problem Statement: Match each term in the equation with the correct description from the following list. (1) Heat, (2) Work, (3) The change in thermal energy



Answer: (a) The change in thermal energy, (b) Work, (c) Heat

1H.L1.1-05

Description: Understanding heat transfer

Learning Objectives: [x,xx,...] Put the learning objective numbers here

Problem Statement: What is the SI unit of heat?

(1) Newton

(2) Pascal
(3) Watt
(4) Joule

Answer: (4)

1H.L1.1-06

Description: internal energy calculation

Learning Objectives: [x,xx,...] Put the learning objective numbers here

Problem Statement: If 5 J are taken away by heat from the system, and the system does 5 J of work on the environment, what is the change in internal energy of the system?

(1) -10 J
(2) 0 J
(3) 10 J
(4) 25 J

Answer: (1)

1H.L1.1-07

Description: internal energy calculations

Learning Objectives: [x,xx,…] Put the learning objective numbers here

Problem Statement: Some amount of energy is transferred by heat into a system. The net work done by the system on the environment is 50 J, while the increase in its internal energy is 30 J. What is the amount of net heat?

(1) -80 J
(2) -20 J
(3) 20 J
(4) 80 J

Answer: (4)

1H.L1.1-08

Description: Understanding internal energy

Learning Objectives: [x,xx,…] Put the learning objective numbers here

Problem Statement: Based on what you know about heat transfer and the first law of thermodynamics, do you need to eat more or less to maintain a constant weight in colder weather? Explain why.

(1) more: as more energy is lost by the body in colder weather, the need to eat increases so as to maintain a constant weight
(2) more: eating more food means accumulating more fat, which will insulate the body from colder weather and will reduce the energy loss
(3) less: as less energy is lost by the body in colder weather, the need to eat decreases so as to maintain a constant weight
(4) less: eating less food means accumulating less fat, so that less energy will be required to burn the fat and, as a result, weight will remain constant

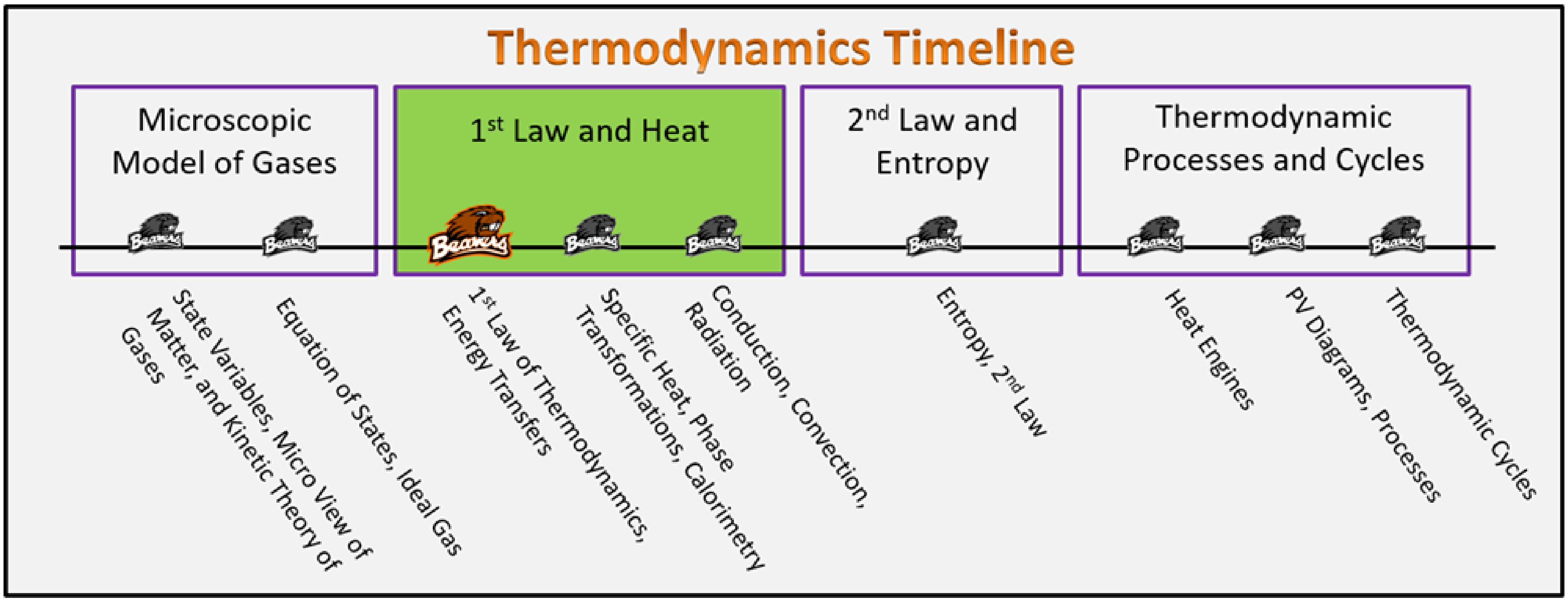
Answer: (1)

(1H.L1.2.sols) Foundation Stage Solutions

Monday, January 22, 2018 5:44 PM

1st Law and Heat
Foundation Stage (1H.2.L1)

Lecture 1
1st Law of Thermodynamics, Energy Transfers



Textbook Chapters (* Calculus version)

- **BoxSand** :: KC videos (First Law of Thermodynamics)

- **Knight** (College Physics : A strategic approach 3rd) :: 10.8 ; 11.1 ; 11.2 ; 11.3 ; 11.4
- ***Knight** (Physics for Scientists and Engineers 4th) :: 19.1 ; 19.3 ; 19.4 ;
- **Giancoli** (Physics Principles with Applications 7th) :: 14-1 ; 14-2 ; 15-1

Warm up

1H.2.L1-1:

Description: Explain the work-energy principle.

Learning Objectives: [?] - Can you identify the objectives from the previous lecture, and this lecture, that this question is relevant to?

Problem Statement: Recall the work-energy principle shown below in the mathematical representation. With your neighbor, discuss everything you about this work-energy principle. For example, what are each term called, conceptually what do the terms represent, what are the functional forms of any of the terms, etc..

$$\Sigma E_i + W_{ext} = \Sigma E_f$$

Selected Learning Objectives

1. Coming soon to a lecture template near you.

Key Terms

- Heat
- 1st Law of Thermodynamics

Key Equations

$$E_{th} = W + Q$$

Key Concepts

- Coming soon to a lecture template near you

Questions

Act I: Heat

1H.2.L1-2:

Description: Conceptual question about heat. (3 minutes)

Learning Objectives: [?]

Problem Statement: Heat is

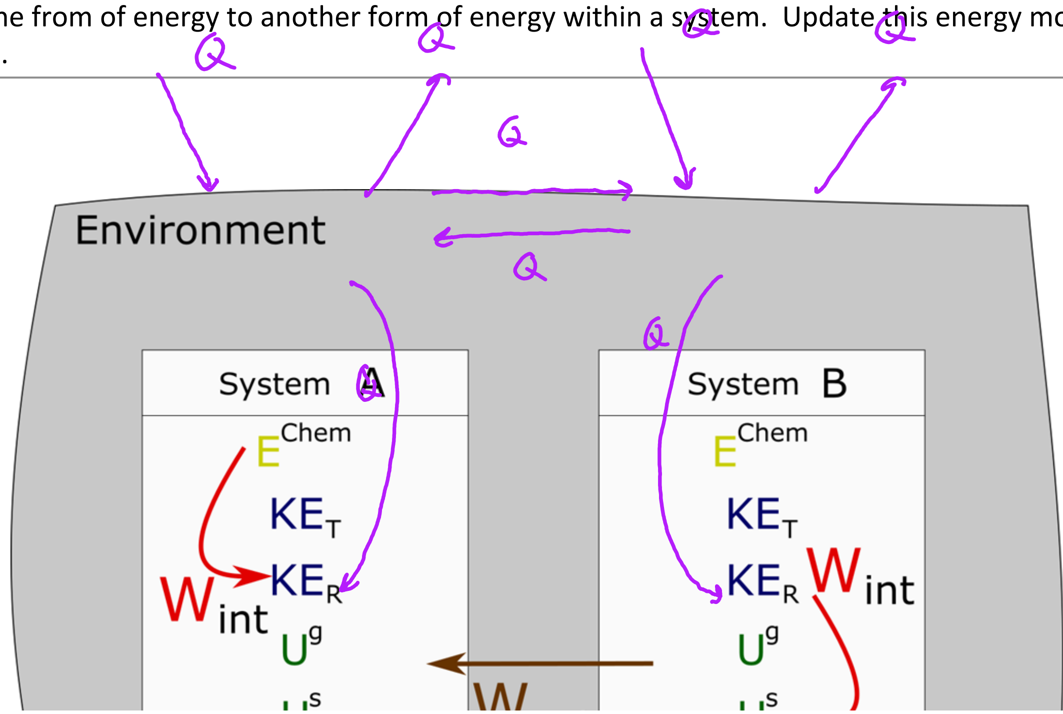
(1) a physical property objects with **T** > 0 K possess.
(2) the amount of thermal energy in an object.
(3) the energy that moves (typically) from a hotter object to a colder object.
(4) a measure of how hot an object it.
(5) one of the two ways to account for energy transfers or transformations.
(6) measured in J.
(7) a term used to represent three new mechanisms of energy transfer.

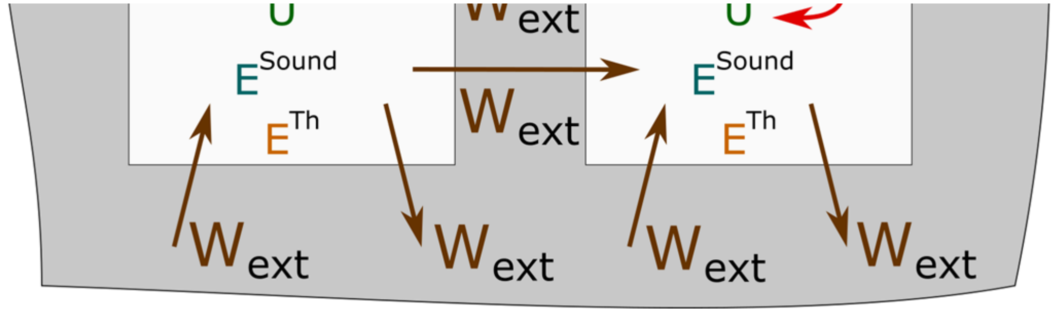
1H.2.L1-3:

Description: Conceptual question about heat and energy model. (4 minutes)

Learning Objectives: [?]

Problem Statement: Consider the blank energy flow diagram below. In general we can define more than one system, here we have two systems **A** and **B**. Anything not included in **A** and **B** is the environment. Our current energy model says that external work is a mechanism to transfer energy into or out of a system. This energy can come from the environment or a different system. Internal work transforms energy from one from of energy to another form of energy within a system. Update this energy model to represent our new knowledge of what heat is.





1H.2.L1-4:

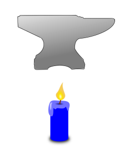
Description: Conceptual question about energy transfer mechanisms; heat vs work. (3 minutes)

Learning Objectives: [?]

Problem Statement: Which of the following processes explicitly involves *heat* as the only mechanism for energy transfer?

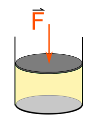
(1) The brakes on your car get hot when you stop.

(2) A steel block is placed over a candle.

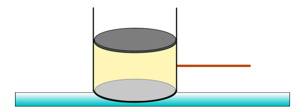


(3) Ice melting in a glass of water.

(4) A piston pushed into a cylinder of gas, increasing the temperature of the gas.



(5) A rigid cylinder of gas being pulled across a frictionless surface.



1H.2.L1-5:

Description: Sketch energy flow diagram for system involving heat. Sketch energy flow diagram for system involving work. (3 minutes).

Learning Objectives: [?]

Problem Statement: Sketch the energy flow diagram that best represents the following scenarios.

(a) A steel block is placed over a candle.

Snapshots were taken of the block at the following times:

- **A:** The moment the steel block is placed over the candle.
- **B:** A few moments later when the candle has increased in temperature.

System: Steel block

Time

System	A	B
E^{Chem}		
KE_T		
KE_R		
U^g		
U^s		
E^{Sound}		
E^{Th}		

(b) A piston pushed into a cylinder of gas, increasing the temperature of the gas. The cylinder is metal and has been sitting in a bath of ice water for a long time.

Snapshots were taken of the gas as the following times:

- **A:** The moment the cylinder full of room temperature gas is placed into the ice container.
- **B:** A few moments later when the piston is being pushed into the cylinder and the temperature of the gas increased.

System: Gas

Environment

Time

System	A	B
E^{Chem}		
KE_T		
KE_R		
U^g		
U^s		
E^{Sound}		
E^{Th}		

Act II: 1st Law of Thermodynamics

$\Delta E^{th} = W + Q$

$= 16\text{ kJ} - 12\text{ kJ}$

1H.2.L1-6:

Description: Apply first law of thermodynamics given work and heat. (2 minutes + 3 minutes + 2 minutes)

$\Delta E^{th} = 4\text{ kJ}$ $\quad \Delta E^{th}(+)$ so $\Delta T(+)$

Learning Objectives: [?]

Problem Statement: In a certain process, 16 kJ of work is done on a system while 12 kJ of heat is extracted.

$\Delta E^{th} = \frac{3}{2} nR\Delta T$

(a) The temperature of the system ______

$4000\text{ J} = \frac{3}{2}(3)(8.314\text{ J/mol K})\Delta T$

$\Delta T \approx 107\text{ K}$

(1) increases
(2) decreases
(3) stays the same

(b) If the system consists of 3 moles of an ideal monatomic gas, how much does the temperature rise? (**R** = 8.314 J/mol·K)

(1) 21 K
(2) 25 K

(3) 67 K
(4) 107 K
(5) 214 K
(6) 301 K

(c) What is the final temperate of the 3 moles of gas after the process is complete?

(1) 67 K
(2) 107 K
(3) 314 K
(4) Unable to determine, need more information.

1H.2.L1-7:

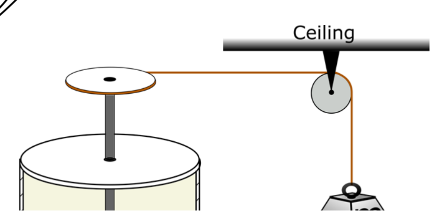
Description: Calculate change in thermal energy of system that includes heat and gravitational energy. (2 minutes + 6 minutes)

Learning Objectives: [?]

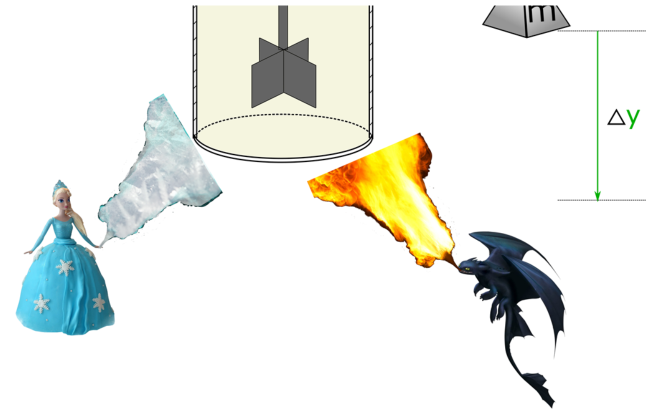
Problem Statement: A paddle wheel frictionally adds thermal energy to 5.0 moles of an ideal monatomic gas in a sealed closed container. The paddle wheel is driven by a cord connected to a falling 2.0 kg mass falling shown in the figure.

(a) Refer to **MG.2.L1-4** where there was zero heat transfer because the system was isolated. The 2 kg mass fell about 32 meters and the temperature of the gas increased by 10 K. Here the system is closed so energy can be transferred into or out of the system. It is discovered that the temperature increased by 8 K doing the same 32 meter drop. Was the chamber next to ice or next to fire?

(1) Ice.
(2) Fire.



$Q = -128\ J$



(b) A paddle wheel frictionally adds thermal energy to 5.0 moles of an ideal monatomic gas in a sealed closed container. The paddle wheel is driven by a cord connected to a falling 2.0 kg mass falling shown in the figure. It is discovered that the temperature increased by 8 K doing the same 32 meter drop. **Calculate the energy transferred via heat. Include the proper sign if the gas is the system.**

$\Delta T(°C) = \Delta T(K)$

1H.2.L1-8:

Description: Calculate how many moles are present given work, heat, and change in temperature. (2 minutes + 2 minutes + 4 minutes)

Learning Objectives: [?]

Problem Statement: In a certain process a monatomic gas does 3 kJ of work on the environment while 5 kJ of heat is added to the system. It is noticed that the temperature of the gas increases by 300 C°.

(a) What is the change in temperature in Kelvin?

(1) Greater than 300 K
(2) Less than 300 K
(3) Equal to 300 K

(b) What is the change in temperature in Fahrenheit?

(1) Greater than 300 F°
(2) Less than 300 F°
(3) Equal to 300 F°

(c) Approximately how many moles are present in the gas?

1H.2.L1-9:

Description: Apply 1st law of thermodynamics in the graphical representation. (3 minutes + 3 minutes + 2 minutes + 2 minutes)

Learning Objectives: [?]

Problem Statement: Power is defined as energy per time. The SI units are J/s which are often referred to as watts "W".

$\frac{\Delta E^{TH}}{\Delta t}$

(a) Which of the following equations is a valid form for the 1st law of thermodynamics?

(1) ΔE^{TH} = $\mathbf{W + Q}$

(2) $\Delta E^{TH}/\Delta t$ = $\mathbf{W + Q}$

(3) ΔE^{TH} = $\mathbf{W/\Delta t + Q/\Delta t}$

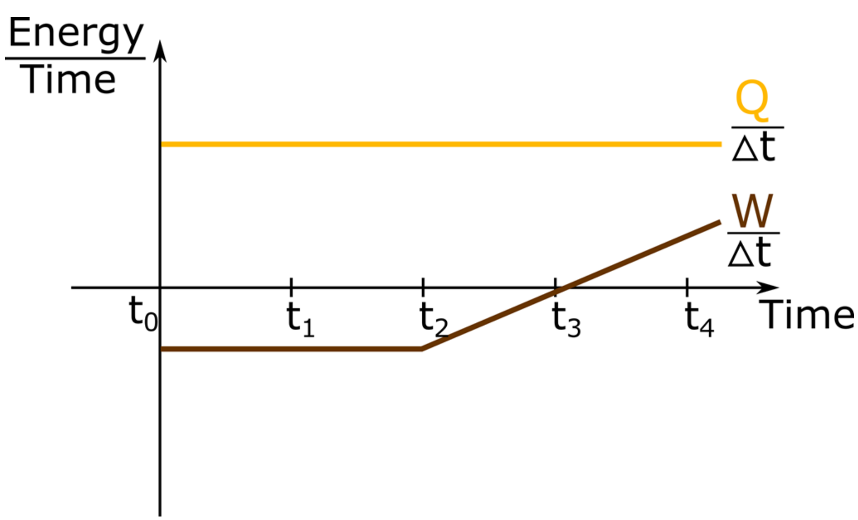
(4) $\Delta E^{TH}/\Delta t$ = $\mathbf{W/\Delta t + Q/\Delta t}$

W(−) (t_0, t_3)

$\frac{\Delta E^{TH}}{\Delta t} = 0$

NEVER IN EQ

(b) The plot below shows the amount of heat and work per time into or out of a system as a function of time. Sketch the change in thermal power as a function of time on the same plot?



(c) During which time interval(s) is the system doing work on the environment?

(d) During which time interval(s) is the system in thermal equilibrium?

Conceptual questions for discussion

1. With your neighbor, discuss why objects can not possess heat.
2. With your neighbor, discuss the differences between the 1st law of thermodynamics and the work-energy theorem.
3. Chemists and Engineers sometimes use the 1st law of thermodynamics in the form ΔE^{th} = **Q** - **W**. Explain the difference between the first law written as ΔE^{th} = **Q** + **W** .

Hints

1H.2.L1-1: Review the work-energy theorem.

1H.2.L1-2: No hints.

1H.2.L1-3: Recall that work is a mechanism for how energy can be transferred into or out of a system as well as a way to transform energy within a system. Compare this definition of work with that of the new quantity, heat.

1H.2.L1-4: Work involves forces acting over distances, heat does not involve this.

1H.2.L1-5: All objects with a temperature greater than 0 K have thermal energy.

1H.2.L1-6: Discuss with you neighbors what is the sign of the work and heat?

1H.2.L1-7: No hints.

1H.2.L1-8: No hints.

1H.2.L1-9: No hints.

(1H.L1.3) Practice Stage

Thursday, March 29, 2018 8:34 PM

1st Law and Heat (1H)

Practice Stage:

Post-lecture 1: 1st Law of Thermodynamics, Energy Transfers

Reading

1. none

Lecture Videos

1. none

Example Problems

1. none

Simulations

1. none

Other Suggested Content

1. none

Practice

1. none

Homework

1H.L1.3-01

Description: using heat transfer in calculations

Learning Objectives: [x,xx,...] Put the learning objective numbers here

Problem Statement: 1 J of energy is added to a beaker of water. How can you tell if the energy was added as work or as heat? (Assume the beaker of water is in equilibrium states before and after the energy is added.)

1. The water will take up less volume if heat is added.
2. There is no way to tell the form of energy that was added.
3. The water will move faster if heat is added.
4. The water's mass will change if heat is added.

Answer: (2)

1H.L1.3-02

Description: internal energy calculation

Learning Objectives: [x,xx,...] Put the learning objective numbers here

Problem Statement: If 5 J are taken away by heat from the system, and the system does 5 J of work on the environment, what is the change in internal energy of the system?

1. −10 J
2. 0 J
3. 10 J

4.	25J

Answer: (1)

1H.L1.3-03

Description: Compare angular acceleration of two objects on the same turntable.

Learning Objectives: [x,xx,...] Put the learning objective numbers here

Problem Statement: An ideal monatomic gas does 15 J of work on the environment while 3 J of energy are transferred into the system via heat. During this process, the temperature of the gas changes by 0.641 K. How many moles of ideal gas are present in this system?

1.	1 mole
2.	1.5 moles
3.	2 moles
4.	0.50 mole

Answer: (2)

1H.L1.3-04

Description: Non-UCM kinematics of a car's crankshaft

Learning Objectives: [x,xx,...] Put the learning objective numbers here

Problem Statement: In a certain process, + 12 J of work is done on 0.25 moles of an ideal gas while 8 J of thermal energy are added via heat. The initial temperature of the gas before this process occurred was 180 K. What is the final temperature of this gas after the process?

1.	180 K
2.	186 K
3.	174 K
4.	6 K

Answer: (2)

1H.L1.3-05

Description: Part 1 - calculating force to hold your head up

Learning Objectives: [x,xx,...] Put the learning objective numbers here

Problem Statement: 1 Kilocalorie is defined as 4184 joules. If you burned 10 calories while doing work on 1 mole of an ideal gas, by how much did the ideal gas temperature change by? Assume the amount of Kilocalories you burned all go into the work on the gas.

1.	0.335 K
2.	3.35 K
3.	33.5 K
4.	335 K

Answer: (2)