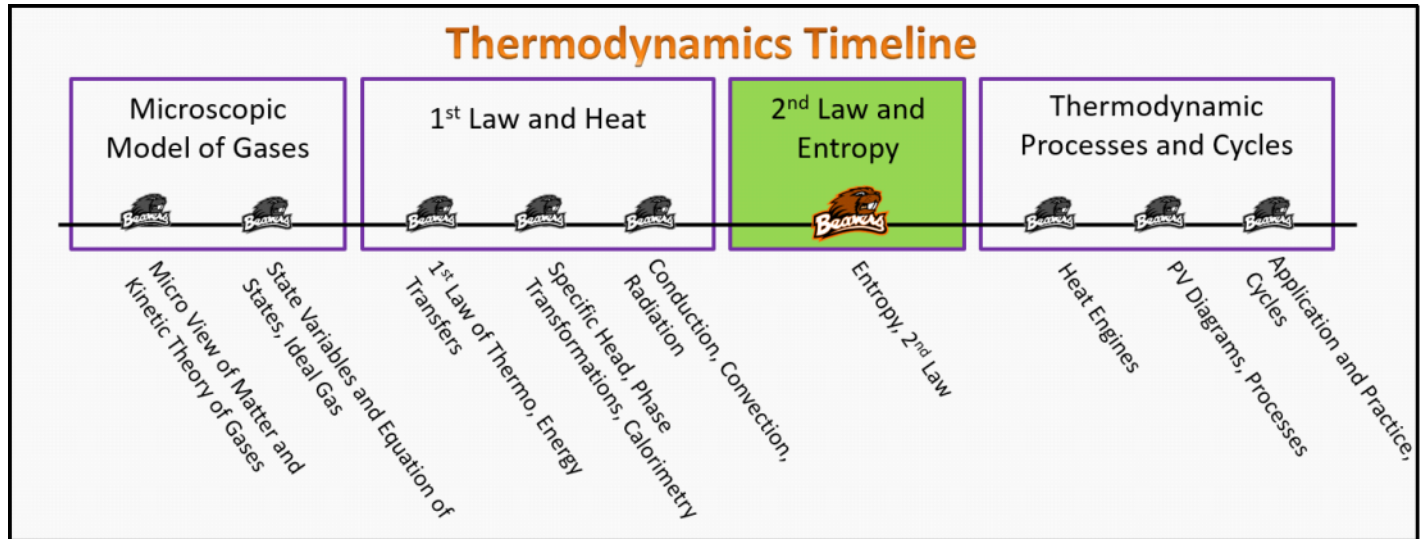


2nd Law and Entropy Familiarize Stage (2E.L1.1)

Lecture 1 Entropy, 2nd Law



2E.L1.1-01

Description: Entropy and order

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

Problem Statement: What is entropy?

- (1) The entropy is a measure of the potential energy of a system.
- (2) The entropy is a measure of the net work done by a system.
- (3) The entropy is a measure of the disorder of a system.
- (4) The entropy is a measure of the heat transfer of energy into a system.

2E.L1.1-02

Description: SI units for entropy

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

Problem Statement: What are the SI units for entropy?

- | |
|---|
| (1) Joules·(Kelvin) ² or (J·K ²) |
| (2) Joules·Kelvin or (J·K) |
| (3) Joules per Kelvin, or J/K |
| (4) Joules per square Kelvin, or (J/K ²) |

2E.L1.1-03

Description: Sign of entropy related to heat

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

Problem Statement: Consider a system where net heat is leaving the system. What happens to the entropy of the system.

- | |
|----------------------|
| (1) increases |
| (2) decreases |
| (3) remains constant |

2E.L1.1-04

Description: Entropy and 2nd law for ice melting

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

Problem Statement: A system consists of ice melting in a glass of water. What happens to the entropy of this system?

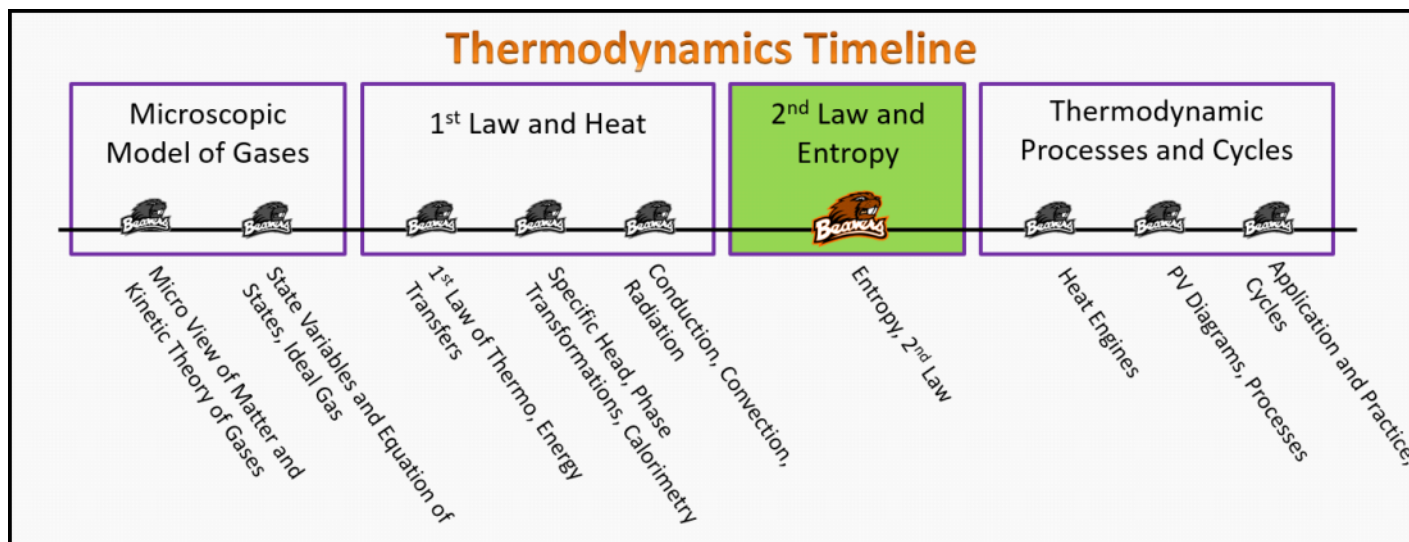
- | |
|---|
| (1) The entropy of the ice decreases, while the entropy of the water cannot be predicted without more specific information. |
| (2) The entropy of the system remains constant |
| (3) The entropy of the system decreases. |
| (4) The entropy of the system increases. |

2nd Law and Entropy

Foundation Stage (2E.L1.2)

Lecture 1

Entropy, 2nd Law



Textbook Chapters (* Calculus version)

- **BoxSand** :: KC videos ([Entropy and 2nd Law of Thermodynamics](#))
- **Knight** (College Physics : A strategic approach 3rd) :: 11.7 ; 11.8
- ***Knight** (Physics for Scientists and Engineers 4th) :: 20.6
- **Giancoli** (Physics Principles with Applications 7th) :: 15-4 ; 15-7 ; 15-8 ; 15-9 ; 15-10

Warm up

2E.L1.2-01:

Description: Describe what you have heard about entropy from other classes or sources.

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

Problem Statement: Have you heard of the word entropy before? If so, list everything you can remember about what you know about entropy.

Selected Learning Objectives

1. Coming soon to a lecture template near you.

Key Terms

- Macroscopic state
- Microscopic state
- Multiplicity
- Probability
- Entropy

Key Equations

Key Concepts

- Coming soon to a lecture template near you.

Questions

Act I: Equilibrium

2E.1.1.2-02:

Description: Conceptual question about equilibrium. (2 minutes + 3 minutes + 2 minutes)

Problem Statement: A box partitioned into two sides via a divider contains 75 L of oxygen on the right hand side and 25 L of oxygen on the left hand side. Both sides are at the same temperature. When the middle divider is removed, the gasses mix.

(a) Are the gases in equilibrium the instant after the divider is removed?

- (1) Yes
- (2) No

(b) What caused the gasses to mix, changing the state of the system?

- (1) Energy gradients
- (2) Entropy gradients
- (3) Configurational drive to equilibrium
- (4) Temperature gradients
- (5) Average momentum gradients

(c) What is the probability that the system will find itself back in the original state with the gasses separated at a later date?

- (1) 75%
- (2) 42%

- (3) 1.2 %
- (4) 0.000001%
- (5) Not zero but close enough to zero to be zero.

2E.L1.2-03:

Description: Identify the most probable macro state. (4 minutes)

Problem Statement: Two coins are tossed at the same time. The table below represents common features of a system. Which is the most probable macroscopic state?

- (1) 2H 0T
- (2) 1H 1T
- (3) 0H 2T
- (4) All equally probable

Macro State Label	Micro State Specification Coin 1 ; Coin 2	Multiplicity	Probability
2H 0T	H ; H	1	
1H 1T	H ; T T ; H	2	
0H 2T	T ; T	1	

Act II: Entropy

2E.L1.2-04:

Description: Identify state of higher entropy. (3 minutes + 2 minutes)

Problem Statement: A box partitioned into two sides via a divider contains 75 L of oxygen on the right hand side and 25 L of oxygen on the left hand side. Both sides are at the same temperature. When the middle divider is removed, the gasses mix.

(a) Which state has the most entropy?

- (1) The two gases separated in their respective sides.
- (2) The two gases mixed together after divider is removed.
- (3) Both states have equal entropy.

(b) Which state has the most microscopic configurations that yield the same macroscopic state?

- (1) The two gases separated in their respective sides.
- (2) The two gases mixed together after divider is removed.
- (3) Both states have equal number of microscopic configurations that yield the same macroscopic state.

2E.L1.2-05:

Description: Determine most probably macro state. Identify evolution of system. (4 minutes + 3 minutes + 2 minutes + 4 minutes).

Problem Statement: A very large number of six-sided die are all initially on a table, all with their 1 side showing. You decide to take two dice at a time and roll them until you have rolled all dice once.

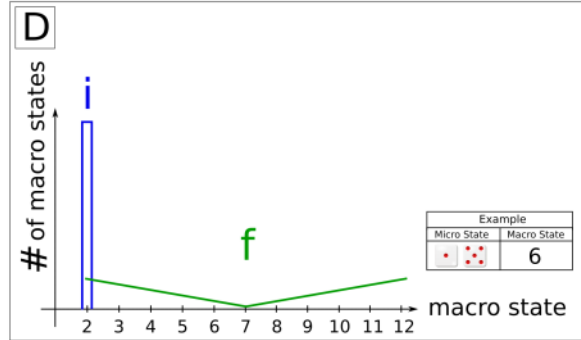
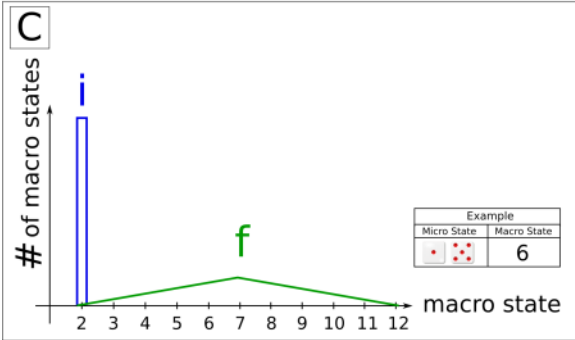
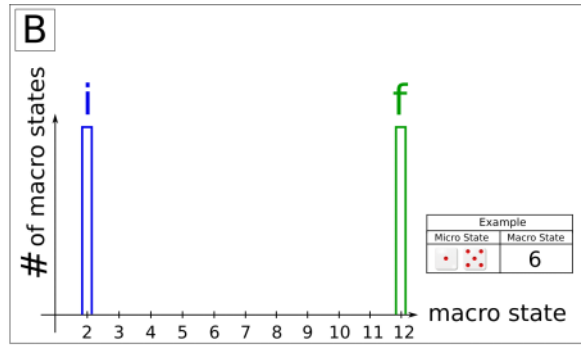
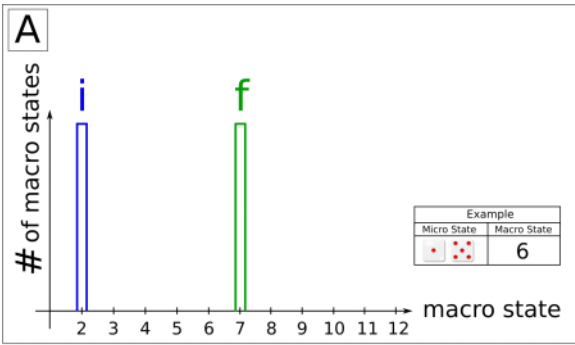
(a) The table to the right shows an example of a possible outcome after rolling two dice. What is the most probable macro state when you roll two dice?

Macro State	Micro State Die 1 ; Die 2	Multiplicity
$1 + 5 = 6$	1 ; 5	5

(b) What is the multiplicity of this most probable macro state?

(c) What is the least probable macro state?

(d) Which of the following plots shows the correct evolution of the system as you go from the initial state of all dice showing 1, to the final state after you have rolled each die many times?



2E.L1.2-06:

Description: Identify entropy increases and/or decreases. (5 minutes)

Problem Statement: A drop of water soluble blue ink ($T = 20\text{ }^{\circ}\text{C}$) falls into an isolated beaker of water ($T = 20\text{ }^{\circ}\text{C}$). Which of the following statements are true regarding the time after the ink drops has landed in the water?

- (1) The entropy of the water + ink system decreases.
- (2) The entropy of the water + ink system increases.
- (3) The entropy of the water + ink system will remain a constant.
- (4) Thermal energy will flow between the ink and the water in accordance with the second law of thermodynamics.
- (5) The system will start and remain in total equilibrium unless it interacts with the outside environment.

2E.L1.2-07:

Description: Identify entropy increases and/or decreases. (6 minutes)

Problem Statement: Water is placed in a freezer and as it comes into thermal equilibrium it freezes. Which of the following statements are true concerning this process?

- (1) The water gains entropy in accordance with the second law of thermodynamics.
- (2) The water loses entropy so the process violates the second law of thermodynamics.
- (3) The water gains entropy, but the air outside the freezer loses entropy in accordance with the second law of thermodynamics.
- (4) Both the water and the air outside the refrigerator lose entropy, but the universe gains entropy in accordance with the second law of thermodynamics.
- (5) The water loses entropy, but the air outside the refrigerator gains entropy in accordance with the second law of thermodynamics.

Conceptual questions for discussion

1. Coming soon.

Hints

2E.L1.2-01: No hints.

2E.L1.2-02: No hints.

2E.L1.2-03: No hints.

2E.L1.2-04: No hints.

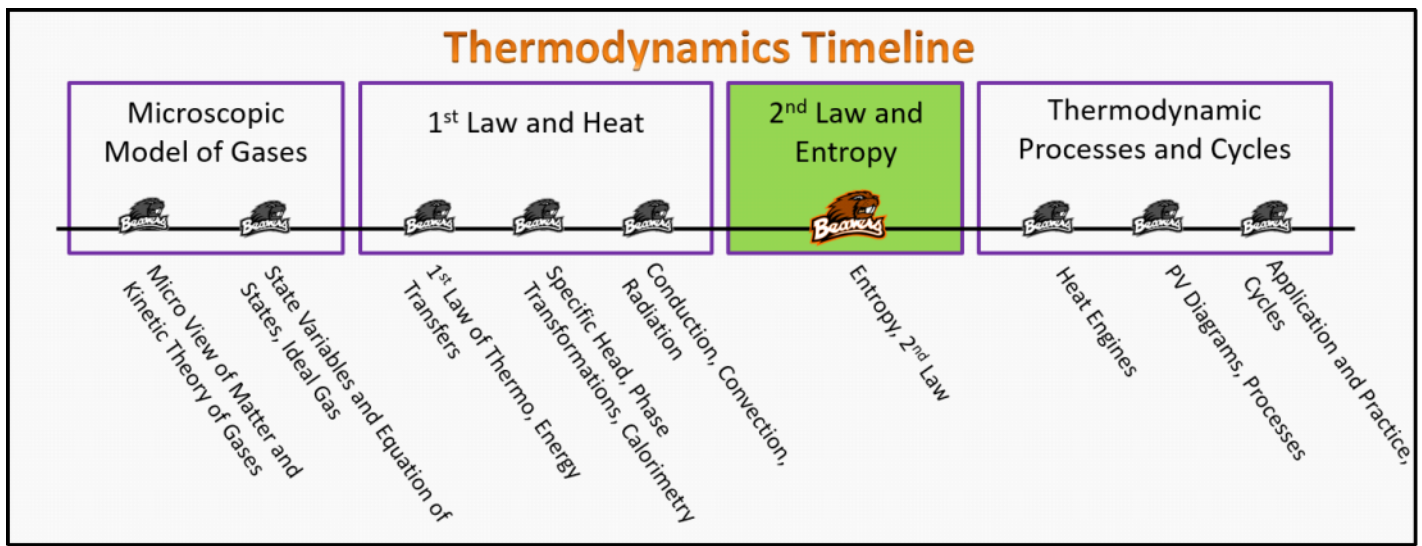
2E.L1.2-05: No hints.

2E.L1.2-06: No hints.

2E.L1.2-07: No hints.

2nd Law and Entropy Practice Stage (2E.L1.3)

Lecture 1 Entropy, 2nd Law



2E.L1.3-01

Description: Determine sign of entropy change.

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

Problem Statement: Water at room temperature is placed into a freezer and turns into ice. What is the sign of the change in entropy of the water for this process?

- (1) positive
- (2) negative
- (3) the entropy of the water doesn't change.

2E.L1.3-02

Description: Determine sign of entropy change.

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

Problem Statement: Water at room temperature is placed on a stovetop which begins to increase the temperature of the water. What is the sign of the change in entropy of the water for this process?

- (1) positive
- (2) negative
- (3) the entropy of the water doesn't change.

2E.L1.3-03a

Description: Rank entropy magnitude.

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

Problem Statement: Consider an closed system consisting of an air compressor and a garage at standard atmospheric pressure. State **A** is the initial state where the air compressor is open to the garage and also at standard atmospheric pressure. State **B** is the final state after the air compressor has been turned on and took air from the garage and stored it in its tank at 100 psi for later use. Which state has a larger entropy?

- (1) A
- (2) B
- (3) Both states have same entropy.

2E.L1.3-03b

Description: Rank entropy magnitude.

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

Problem Statement: Consider an closed system consisting of an air compressor and a garage at standard atmospheric pressure. State **A** is the initial state where the air compressor is open to the garage and also at standard atmospheric pressure. State **B** is the final state after the air compressor has been turned on and took air from the garage and stored it in its tank at 100 psi for later use. Which state has the most microscopic configurations that yield the same macroscopic state?

- (1) A
- (2) B
- (3) Both states have the same micro configurations that yield the same macro state.