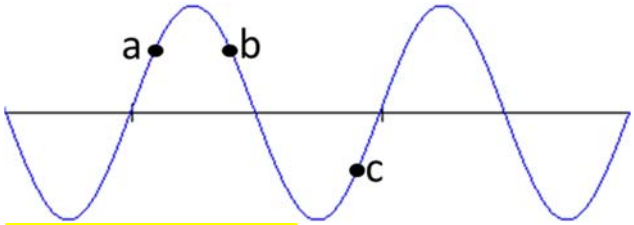
Q1. A sinusoidal travelling wave in a string is given by equation $y = y_m \sin(kx + \omega t)$ and its snap shot at an instant is shown in **FIGURE 1**. Three string elements are indicated by the lettered points. Which of the following is correct about the direction of motion of the string elements **a**, **b**, and **c** at the instant of the snap shot.



A) a-up, b-down, c-up
B) a-up, b-up, c-down
C) a-down, b-down, c- up
D) a-down, b-up, c-down
E) a-up, b-down, c-down

Q2. Two sinusoidal waves, identical except for phase, travel in the same direction along a string are given by

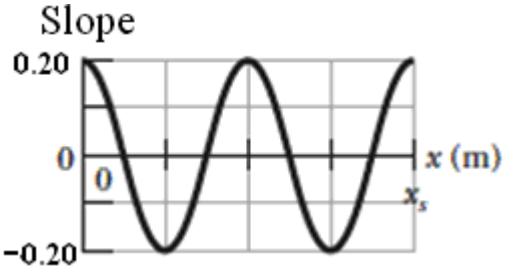
$y_1 = 0.025\sin(15.0x - 90.0t)$

$y_2 = 0.025\sin(15.0x - 90.0t + \pi/3)$

Where x, y are in m and t is in s. At what average rate does the resultant wave transport the energy? (μ = 500 g/m for the string)

A) 22.8 W
B) 17.5 W
C) 12.3 W
D) 7.58 W
E) 9.37 W

Q3. A sinusoidal wave travels along a string under tension. **FIGURE 2** gives the slopes (of string elements) along the string at time t = 0. The scale of the x-axis is set by x_s = 0.80 m. what is the amplitude of the wave?



A) 1.3 cm
B) 0.20 cm
C) 0.40 cm
D) 2.1 cm
E) 1.8 cm

Q4. A rope, under a tension of 200 N and fixed at both ends, oscillates in a second-harmonic standing wave pattern. The displacement of the rope is given by:
$y = (0.10\ \text{m})\ (\sin \pi x/2)\ (\cos 12\pi t)$
where $x = 0$ at one end of the rope, x is in meters, and t is in seconds. What is the speed of the waves on the rope?

A) 24 m/s
B) 12 m/s
C) 6.0 m/s
D) 36 m/s
E) 18 m/s

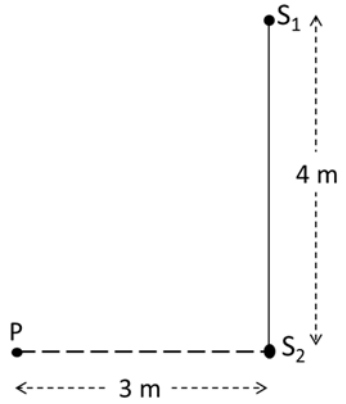
Q5. In an experiment on standing waves, a string 90 cm long is attached to an oscillator that oscillates at a frequency of 80 Hz. The mass of the string is 0.044 kg. Find the tension in the string if it is oscillating in four loops.

A) 63 N
B) 1.8 N
C) 34 N
D) 27 N
E) 51 N

Q6. A man strikes one end of a rod with a hammer. The speed of sound in the rod is 15.0 times the speed of sound in air. A man, at the other end with his ear close to the rod, hears the sound of the blow twice with a 0.120 s interval between them; one sound comes through the rod and the other comes through the air along-side of the rod. If the speed of sound in air is 343 m/s, what is the length of the rod?

A) 44.1 m
B) 617 m
C) 41.2 m
D) 246 m
E) 17.3 m

Q7. Two sound sources S_1 and S_2, shown in **FIGURE 3** are driven by the same oscillator whose frequency is 686 Hz. They are located at distance of 4.0 m on a vertical line. If you slide a microphone from point P to S_2 along the horizontal line PS_2, how many time(s) the microphone will detect minimum in sound intensity along this line. (speed of sound 343 m/s)

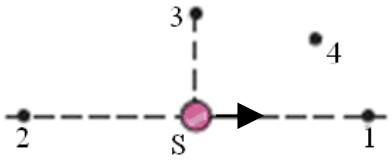


A) Four
B) One
C) Three
D) None
E) Two

Q8. Suppose that the sound level of a sound is initially at 70.0 dB and then drops to 50.0 dB. Assuming that the frequency of the sound is 600 Hz, determine the ratio between initial sound wave amplitude S_{m1} to final sound wave amplitude S_{m2} (i.e. S_{m1}/S_{m2}).

A) 10.0
B) 100
C) 1.40
D) 1.96
E) 0.0150

Q9. **FIGURE 4** shows a moving sound source S that emits at a certain frequency, and four stationary sound detectors (located at points 1, 2, 3, and 4). Rank the detectors according the frequency of the sound they detect from the source, **GREATEST FIRST**.(The source is moving towards the detector **1**).



A) 1, 4, 3, 2
B) 1 and 2 tie, 3, 4
C) 3, 4, then 1 and 2 tie
D) 3, 4, 1, 2
E) 4, 3, 2, 1

Q10. Suppose that on a linear temperature scale X, water boils at – 53.5 ^oX and freezes at – 170 ^oX. What is a temperature of 340 K on the X scale?(0 ^oC = 273 K)

A) −91.9 ^oX
B) −211 ^oX
C) −58.7 ^oX
D) +50.2 ^oX
E) +83.7 ^oX

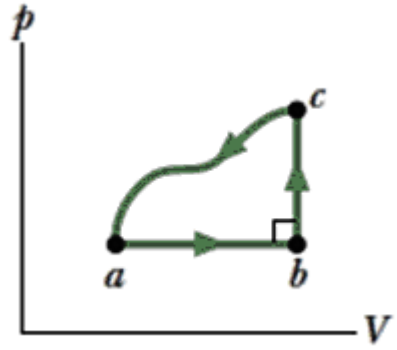
Q11. What is the change in density of an aluminum cube of mass 200 g and of edge length 5.0 cm when heated from 10 ^oC to 80^oC (coefficient of linear expansion of aluminum 23 × 10^{-6} /^oC).

A) 7.7×10^{-3} g/cm^3
B) 5.0×10^{-1} g/cm^3
C) 3.3 g/cm^3
D) 2.4×10^{-3} g/cm^3
E) 9.7×10^{-2} g/cm^3

Q12. Materials A, B, and C are solids that are at their melting temperatures. Material A requires 200 J to melt 4 kg, material B requires 300 J to melt 5 kg, and material C requires 300 J to melt 6 kg. Rank the materials according to their heats of fusion, **GREATEST FIRST**.

A) B, then A and C tie
B) B and C tie, A
C) C, B, A
D) A, B, C
E) A, B and C all tie

Q13. **FIGURE 5** displays a closed cycle for a gas. The change in internal energy along path **ca** is −160 J. The energy transferred to the gas as heat is 200 J along **ab**, and 40.0 J along path **bc**. How much work is done by the gas along path **abc**?



A) 80.0 J
B) 400 J
C) 0.00 J
D) 200 J
E) 40.0 J

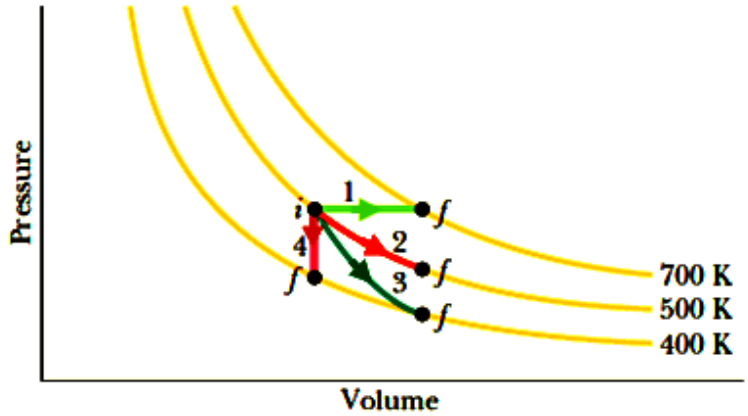
Q14. Suppose 1.80 mol of an ideal gas is taken from a volume of 3.00 cm^3 to a volume of 1.50 cm^3 via an isothermal compression at 30.0 °C. How much energy is transferred as heat during the compression.

A) -3.14×10^3 J
B) $+3.14 \times 10^3$ J
C) $+2.95 \times 10^2$ J
D) -2.95×10^2 J
E) $+5.63 \times 10^3$ J

Q15. A cylinder contains a mixture of helium (He) and argon (Ar) gas in equilibrium at 150 °C. Find the ratio of root-mean-square speed of helium to that of argon (V_{He}:V_{Ar}). (molar masses of helium and argon are 4.00 g/mole and 40.0 g/mole, respecticvely).

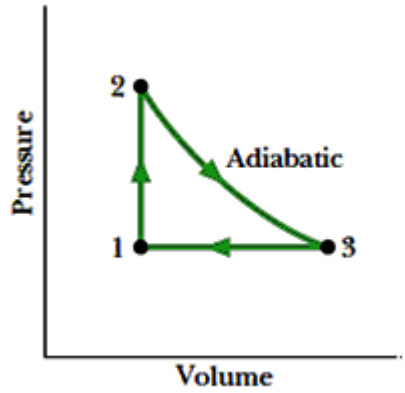
A) 3.16
B) 0.172
C) 4.00
D) 0.250
E) 6.32

Q16. Rank the four paths of **FIGURE 6** according to the change in the internal energy of the gas, **MOST POSITIVE FIRST** and most negative last.



A) 1, 2, then 3 and 4 tie
B) 1 and 2 tie, then 3 and 4 tie
C) 2,1, 3, 4
D) 1 and 4 tie, 2, 3
E) 4, 3, 2, 1

Q17. One mole of an ideal monoatomic gas passes through a cycle as shown in **FIGURE 7**. The temperatures $T_1 = 300.0$ K, $T_2 = 600.0$ K, and $T_3 = 455.0$ K. What is the work done for path $2 \rightarrow 3$?

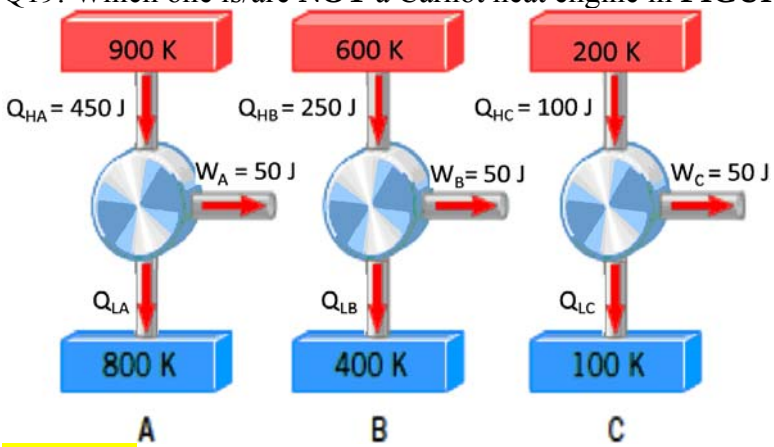


A) +1807 J
B) –1807 J
C) +1353 J
D) –1353 J
E) +9752 J

Q18. 0.300 kg of water at 90.0 ºC and 0.700 kg of water at 10.0 ºC are mixed together in an isolated container and come to equilibrium. Determine the change in entropy of the system of 1.00 kg of water.

A) +28.1 J/K
B) +239 J/K
C) −210 J/K
D) −13.2 J/K
E) +550 J/K

Q19. Which one is/are **NOT** a Carnot heat engine in **FIGURE 8**?



A) B only
B) C only
C) A and B
D) A and C
E) B and C

Q20. An ideal refrigerator utilizes a Carnot cycle operating between 0 °C and 25 °C. To turn 10 kg of liquid water at 0 °C into 10 kg of ice at 0 °C how much energy must be supplied to the refrigerator?

A) 3.0×10^5 J
B) 3.6×10^6 J
C) 4.3×10^6 J
D) 1.7×10^5 J
E) 5.9×10^5 J