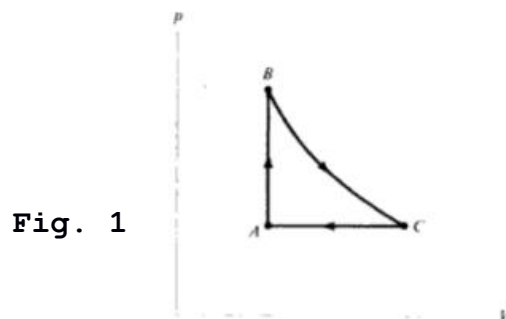
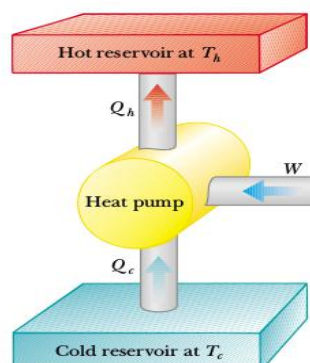


Thermodynamics

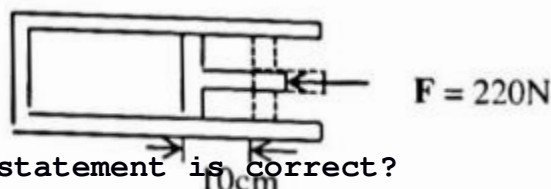
- 1] What is the change in internal energy of 0.1 mol of nitrogen gas as it is heated from 10°C to 30°C at:
 - A) a constant volume and
 - B) a constant pressure.
 ($C_v = 4.96 \text{ cal/mol.K}$)
- 2] When 50 L of air at STP is isothermally compressed to 10 L, how much heat must flow from the gas? ($P_{\text{atm}} = 100\text{kPa}$ and $T = 27^{\circ}\text{C} = 300\text{K}$)
- 3] An ideal gas in a cylinder is compressed adiabatically to one-third its original volume. During the process, 45J of work is done on the gas by the compressing agent.
 - A) By how much did the internal energy of the gas change in the process?
 - B) How much heat flowed into the gas?
- 4] Find the change in internal energy of the system that absorbs 500cal of heat and at the same time does 400J of work.
- 5] Find the change in internal energy for a 5cm cube of iron as it is heated from 20°C to 320°C . For iron, $c = 0.1 \text{ cal/g.K}$ and the volume coefficient of thermal expansion is $3.5 \times 10^{-5}/\text{K}$. The mass of the cube is 1500 g. Assume that the pressure to be atmospheric, $1 \times 10^5\text{Pa}$.
- 6] A cubic meter of 2 mole of helium originally at 0°C and 1atm pressure is cooled at constant pressure until the volume is 0.75 m^3 . How much heat was removed?
- 7] A sample containing 1kmol of the nearly ideal gas helium is put through the cycle of operations shown in Fig. 1. BC is ab isothermal, and $p_A = 1\text{atm}$, $V_A = 22.4\text{m}^3$, $p_B = 2\text{atm}$. What are T_A , T_B , and V_C .



- 8] Refer to Q.7 and calculate the work output during the cycle.
- 9] The highest theoretical efficiency of a certain engine is 30.0%. If this engine uses the atmosphere, which has a temperature of 300 K, as its cold reservoir, what is the temperature of its hot reservoir?
- 10] A freezer has a coefficient of performance of 5. If the temperature inside the freezer is -20°C , what is the temperature at which it ejects heat?



- 11] If the internal energy of the system decreases, then what can be concluded about the heat and the work done?
- Heat is added to the system and work is done by the system.
 - Heat is removed from the system and work is done on the system.
 - Heat is added to the system and work is done on the system.
 - Heat is removed from the system and work is done by the system.
- 12] If a thermodynamic system undergoes a process in which its internal energy increased by 400J while doing 200J of work on its surrounding, then what is the energy absorbed in or extracted from it in the form of heat?
- 13] Which of the following statement is NOT correct?
- A system can absorb heat from a hot reservoir and can convert it entirely into work without additional changes in the system and its surroundings.
 - No process is possible in which there is an overall decrease in the entropy of the universe.
 - The complete conversion of energy from hot source into work is not possible.
 - The spontaneous transfer of energy from a cooler body to hotter body is quite possible.
- 14] A heat engine operating between 100°C and 700°C has efficiency equal to 40% of the maximum theoretical efficiency. How much energy does this engine extract from the hot reservoir in order to do 5000J of mechanical work?
- 15] External force of 220 N applied on a piston of a cylinder containing 1.25g of ammonia gas move 10 cm as shown in the diagram below. Assuming adiabatic process, what is the rise in temperature of the gas? (Specific heat capacity of ammonia, $c = 2200\text{J/kg.K}$)



- 16] Which of the following statement is correct?
 {Here ρ is the density of an ideal gas, m is the mass of the gas, P is the pressure of an ideal gas and c is the speed of the particles}
- $P = \frac{1}{2} \rho \langle c^2 \rangle$
 - For a mixture of two gases in equilibrium in a container,

$$\frac{\rho_2^2}{\rho_1^2} = \frac{\langle c_1^2 \rangle}{\langle c_2^2 \rangle}$$
 - For a mixture of two gases in equilibrium in a container,

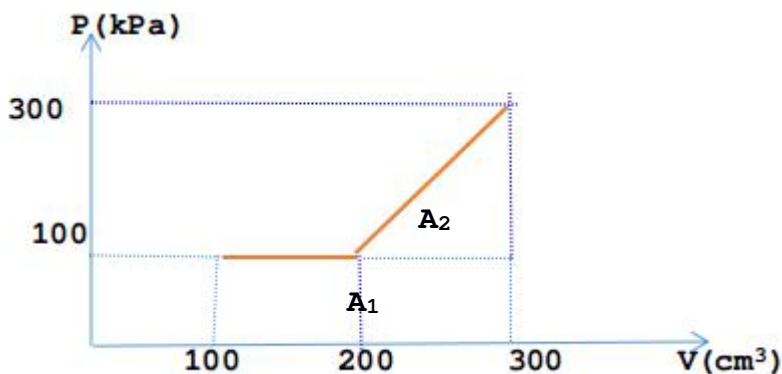
$$\frac{\rho_2^2}{\rho_1^2} = \frac{\langle c_2^2 \rangle}{\langle c_1^2 \rangle}$$
 - For a mixture of two different gases with equal partial pressure and equal number of molecules in a container,

$$\frac{m_2}{m_1} = \frac{\langle c_1^2 \rangle}{\langle c_2^2 \rangle}$$
- 17] What is the change in entropy of 1.00 kg of liquid water at 100°C as it changes to steam at 100°C ?

- 18] Show that the work done by an ideal gas in expanding adiabatically from a state of (P_1, V_1) to a state of (P_2, V_2) is given by:

$$W_{\text{adia}} = \frac{P_1 V_1 - P_2 V_2}{\gamma - 1}$$

- 19] An ideal gas expands at constant pressure of 200 cm-Hg, from 250 cm³ to 750 cm³. It is then allowed to cool at constant volume to its original temperature. What amount of heat flows into the gas during the entire process?
- 20] Find the work done during the thermodynamic process shown on the PV-diagram below.



- 21] The temperature of 0.2kg of nitrogen (N_2) gas is raised from 20°C to 80°C. Find the internal energy and the external work done by the gas, if the rise in temperature is done:

- I) at constant volume, and
- II) at constant pressure.

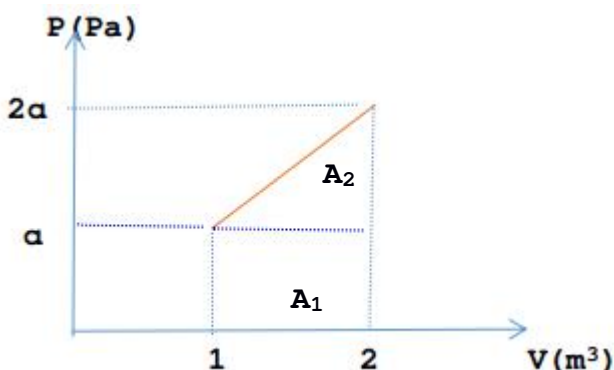
For N_2 gas, $c_v = 0.17$ cal/g.K and $c_p = 0.248$ cal/g.K

- 22] A sample of gas is expanded to twice its original volume of 1 m³ in a quasi-static process for which $p = \alpha V$, $\alpha = 5 \times 10^5$ N/m⁵. How much work was done by the expanding gas?

Since the pressure depends on the volume within the relation relationship, we can sketch the PV curve to determine the work done.

$$V_1 = 1\text{m}^3, P_1 = \alpha V_1 = \alpha \text{ Pa}$$

$$V_2 = 2\text{m}^3, p_2 = \alpha V_2 = 2\alpha \text{ pa}$$

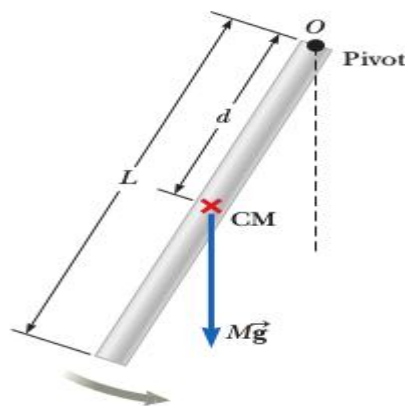


- 23] Calculate the temperature at which the rms speed of oxygen molecules is twice as great as their rms at 27°C.
- 24] An ideal gas undergoes an isothermal process starting with a pressure of 2×10^5 Pa and a volume of 6 cm³. Which one of the following might be the pressure and volume of the final state?
- A. 4×10^5 Pa and 4 cm³
 - B. 4×10^5 Pa and 3 cm³
 - C. 5×10^5 Pa and 3 cm³
 - D. 10^5 Pa and 10 cm³

- 25] If 2 moles of oxygen gas are confined to a 5 liter vessel at a pressure of 8 atm, what is the average kinetic energy of an oxygen molecule under this condition?

Oscillations and Waves

- 26] An object of mass m is hung from a spring and set into oscillation. The period of the oscillation is measured and recorded as T . The object of mass m is removed and replaced with an object of mass $2m$. When this object is set into oscillation, what is the period of the motion?
- A. $2T$ C. $\sqrt{2} T$
B. T D. $T/2$
- 27] A 200 g block connected to a light spring for which the force constant is 5.00 N/m is free to oscillate on a frictionless, horizontal surface. The block is displaced 5.00 cm from equilibrium and released from rest. Determine the maximum speed and the maximum acceleration of the block.
- 28] A 0.5 kg cart connected to a light spring for which the force constant is 20.0 N/m oscillates on a frictionless, horizontal air track. What is the velocity of the cart when the position is 2.00 cm?
- 29] Refer to Q.28 above, compute the kinetic and potential energies of the system when the position of the cart is 2.00 cm. Also, determine the amplitude of the oscillation.
- 30] A uniform rod of mass M and length L is pivoted about one end and oscillates in a vertical plane see (Fig. below). Find the period of oscillation if the amplitude of the motion is small.



- 31] If a simple pendulum oscillates with small amplitude and its length is doubled, what happens to the frequency of its motion?
- A. It doubles
 - B. It becomes $1/\sqrt{2}$ times as large
 - C. It becomes $\sqrt{2}$ times as large
 - D. It remains the same
- 32] A block-spring system vibrating on a frictionless, horizontal surface with an amplitude of 6.0 cm has an energy of 12 J. If the block is replaced by one whose mass is twice the mass of the original block and the amplitude of the motion is again 6.0 cm, what is the energy of the system?
- A. 12 J
 - B. 6 J
 - C. 24 J
 - D. 48 J
- 33] An object-spring system moving with simple harmonic motion has an amplitude A. When the kinetic energy of the object equals twice the potential energy stored in the spring, what is the position x of the

object?

A. A

C. $1/3$ A

B. $A/\sqrt{3}$

D. 0

34] An object of mass 0.40 kg, hanging from a spring with a spring constant of 8.0 N/m, is set into an up-and-down simple harmonic motion. What is the magnitude of the acceleration of the object when it is at its maximum displacement of 0.10 m?

A. 0.45 m/s²

C. 1.0 m/s²

B. 2.0 m/s²

D. 2.4 m/s²

35] The position of an object moving with simple harmonic motion is given by $x = 4 \cos(6\pi t)$, where x is in meters and t is in seconds. What is the period of the oscillating system?

A. 4 s

C. $1/6$ s

B. $1/3$ s

D. 6π s

36] The position of a particle is given by the expression:

$x = 4 \cos(3\pi t + \pi)$, where x is in meters and t is in seconds. Determine the speed of the wave at $t = 1/2$ sec.

37] A wave is described by $y = 0.02 \sin(kx - \omega t)$, where $k = 2$ rad/m, $\omega = 3$ rad/s, x and y are in meters, and t is in seconds. Determine
(a) the amplitude,
(b) the wavelength,
(c) the frequency, and
(d) the speed of the wave.

c) Using the value of angular frequency, it is possible to calculate the normal frequency as:

$$\omega = 2\pi f$$

$$3 = 2\pi f$$

$$f = 3/2\pi \text{ Hz}$$

d) The wave speed is:

$$v = \lambda f = (\pi)(3/2\pi) \text{ m/s} = 3/2 = 1.5 \text{ m/s}$$

38] A transverse wave on a string is described by the wave function

$$y(x, t) = 0.350 \sin(1.25x + 99.6t)$$

where x and y are in meters and t is in seconds. Consider the element of the string at $x = 0$. What is the time interval between the first two instants when this element has a position of $y = 0.175$ m?

39] Two identical machines are positioned the same distance from a worker. The intensity of sound delivered by each operating machine at the worker's location is $2.0 \times 10^{27} \text{ W/m}^2$.

(A) Find the sound level heard by the worker when one machine is operating.

(B) Find the sound level heard by the worker when two machines are operating.

40] A submarine (sub A) travels through water at a speed of 8.00 m/s, emitting a sonar wave at a frequency of 1 400 Hz. The speed of sound in the water is 1 533 m/s. A second submarine (sub B) is located such that both submarines are traveling directly toward each other. The second submarine is moving at 9.00 m/s.

(A) What frequency is detected by an observer riding on sub B as the subs approach each other?

(B) The subs barely miss each other and pass. What frequency is detected

by an observer riding on sub B as the subs recede from each other?

- 41] A family ice show is held at an enclosed arena. The skaters perform to music with level 80.0 dB. This level is too loud for your baby, who yells at 75.0 dB.

- (a) What total sound intensity engulfs you?
(b) What is the combined sound level?

- 42] Show that the difference between decibel levels β_1 and β_2 of a sound is related to the ratio of the distances r_1 and r_2 from the sound source by:

$$\beta_2 - \beta_1 = 20 \log \left(\frac{r_1}{r_2} \right)$$

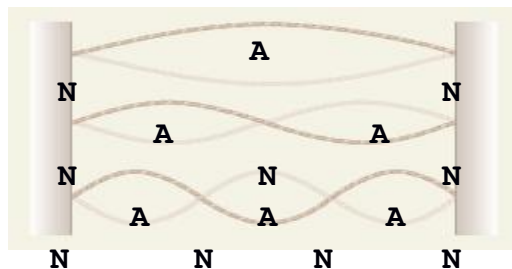
- 43] Two waves traveling in opposite directions produce a standing wave. The individual wave functions are

$$y_1 = 4.0 \sin(3.0x - 2.0t)$$

$$y_2 = 4.0 \sin(3.0x + 2.0t)$$

where x and y are measured in centimeters and t is in seconds.

- (A) Find the amplitude of the simple harmonic motion of the element of the medium located at $x = \pi/6$ cm.
(B) Find the positions of the nodes and antinodes if one end of the string is at $x = 0$.
44] When a standing wave is set up on a string fixed at both ends, which of the following statements is true?
A. The number of nodes is equal to the number of antinodes.
B. The wavelength is equal to the length of the string divided by an integer.
C. The frequency is equal to the number of nodes times the fundamental frequency.
D. The shape of the string at any instant shows a symmetry about the midpoint of the string.



- 45] The middle C string on a piano has a fundamental frequency of 262 Hz, and the string for the first A above middle C has a fundamental frequency of 440 Hz.

- A) Calculate the frequencies of the next two harmonics of the C string. Knowing that the fundamental frequency is $f_1 = 262$ Hz, find the frequencies of the next harmonics by multiplying by integers:
B) If the A and C strings have the same linear mass density m and length L , determine the ratio of tensions in the two strings.

Write expressions for the fundamental frequencies of the two strings:

- 46] Two identical piano strings of length 0.750 m are each tuned exactly to 440 Hz. The tension in one of the strings is then increased by 1.0%. If they are now struck, what is the beat frequency between the fundamentals of the two strings?

- 47] A standing wave having three nodes is set up in a string fixed at both ends. If the frequency of the wave is doubled, how many antinodes will there be? (a)

A. 2
B. 4

C. 3
D. 5



- 48] A flute has a length of 58.0 cm. If the speed of sound in air is 343 m/s, what is the fundamental frequency of the flute, assuming it is a tube closed at one end and open at the other?

A. 148 Hz
B. 444 Hz

C. 296 Hz
D. 591 Hz

- 49] The third overtone produced by a vibrating string is 1200 Hz. What are the frequencies of the lower overtones and of the fundamental? What is the velocity of propagation?

- 50] A 160 cm long string has two adjacent resonances at frequencies of 85 and 102 Hz.

A) What is the fundamental frequency of the string?
B) What is the length of a segment at the 85 Hz resonance?
C) What is the speed of the waves on the string?

Wave optics

- 51] Which of the following causes the fringes in a two-slit interference pattern to move farther apart?

A. decreasing the wavelength of the light
B. decreasing the screen distance D
C. decreasing the slit spacing s
D. immersing the entire apparatus in water

- 52] A viewing screen is separated from a double slit by 4.80 m. The distance between the two slits is 0.03 mm. Monochromatic light is directed toward the double slit and forms an interference pattern on the screen. The first dark fringe is 4.50 cm from the center line on the screen.

A) Determine the wavelength of the light.
B) Calculate the distance between adjacent bright fringes.

- 53] A light source emits visible light of two wavelengths: $\lambda = 430$ nm and $\lambda^* = 510$ nm. The source is used in a double-slit interference experiment in which $D = 1.50$ m and $s = 0.025$ mm. Find the separation distance between the third-order bright fringes for the two wavelengths.

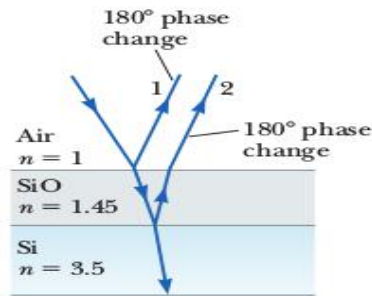
To find the fringe positions corresponding to these two wavelengths, subtract them and substitute numerical values:

- 54] Calculate the minimum thickness of a soap-bubble film that results in constructive interference in the reflected light if the film is illuminated with light whose wavelength in free space is $\lambda = 600$ nm. The index of refraction of the soap film is 1.33.

The minimum film thickness for constructive interference in the reflected light corresponds to $m = 0$ will be:

- 55] Solar cells—devices that generate electricity when exposed to sunlight—are often coated with a transparent, thin film of silicon monoxide (SiO , $n = 1.45$) to minimize reflective losses from the surface. Suppose a silicon solar cell ($n = 3.5$) is coated with a thin film of silicon monoxide for this purpose (see Fig. below). Determine the

minimum film thickness that produces the least reflection at a wavelength of 550 nm, near the center of the visible spectrum.



- 56] A monochromatic beam of light of wavelength 500 nm illuminates a double slit having a slit separation of 2.00 mm. What is the sine angle of the second-order bright fringe?
- 57] Light of wavelength 600 nm illuminates a pair of slits separated by 0.300 mm. If a screen is placed 2.00 m from the slits, determine the distance between the first and second dark fringes.
- 58] Light of wavelength 600 nm falls on a double slit, and the first bright fringe of the interference pattern is seen at an angle of 30.0° with the horizontal. Find the separation between the slits.
- 59] When a soap bubble is in air, it exhibits different colors under sunlight. The absence of a particular color in a region is due to:
- double refraction
 - straight line propagation of light
 - destructive interference of light of that color in that region
 - constructive interference of light of that color in that region
- 60] Two separate coherent sources produce waves whose wavelengths are 0.1m. Which statement is correct about points that are 3.2m away from one source?
- Constructive interference occurs if the points are 3.0m from the other source.
 - Constructive interference occurs if the points are 3.05m from the other source.
 - Constructive interference occurs if the points are 2.95m from the other source.
 - Destructive interference occurs if the points are 3.2m from the other source.
- 61] In Young's double slit experiment, the separation distance between the slits is halved and the distance between the slit and the screen is doubled. The fringe width is:
- be doubled
 - be halved
 - be quadrupled
 - remains the same
- 62] Waves from two slits are in phase at the slits and travel to a distant screen to produce the second minimum of the interference pattern. The difference in the distance traveled by the waves is:
- half a wavelength
 - three halves of a wavelength
 - a wavelength
 - two wavelengths
- 63] The colors seen from soap bubbles and oil slicks are a manifestation of thin film interference. What is the cause of this interference?
- Interference from refraction of light
 - Interference from reflection of light from the two surfaces of

the film

C. Interference from diffraction of light

D. Interference from superposition of lights that are incident and refracted

64] Why is an interference pattern NOT observed between the lights produced from a pair of car headlights?

A. The light sources are not collimated.

B. Interference is observed only in laboratory conditions.

C. The spread of light as it travels out of the source.

D. The light sources are not coherent.

65] Light of wavelength 580 nm is incident on a slit having a width of 0.3mm. The viewing screen is 2 m from the slit. Find the width of the central bright fringe.

66] Monochromatic light from a helium-neon laser ($\lambda = 632.8$ nm) is incident normally on a diffraction grating containing 6000 grooves per centimeter. Find the angles at which the first- and second-order maxima are observed.

67] A Fraunhofer diffraction pattern is produced on a screen located 1.00m from a single slit. If a light source of wavelength 5.00×10^{-7} m is used and the distance from the center of the central bright fringe to the first dark fringe is 5.00×10^{-3} m, what is the slit width?

68] Consider a wave passing through a single slit. What happens to the width of the central maximum of its diffraction pattern as the slit is made half as wide?

A. It becomes one-fourth as wide.

B. It becomes one-half as wide.

C. Its width does not change.

D. It becomes twice as wide.

69] Light of wavelength 600 nm passes through a slit of width 0.200 mm.

(a) The width of the central maximum on a screen is 8.00 mm. How far is the screen from the slit?

(b) Determine the width of the first bright fringe to the side of the central maximum.

70] A screen is placed 50.0 cm from a single slit, which is illuminated with light of wavelength 750 nm. If the distance between the first and third minima in the diffraction pattern is 3.00 mm, what is the width of the slit?

71] The reason there are two slits, rather than one, in a Young's experiment is:

A. to increase the intensity

B. one slit is for frequency, the other for wavelength

C. to create a path length difference

D. one slit is for E fields, the other is for B fields

72] Light from a small region of an ordinary incandescent bulb is passed through a yellow filter and then serves as the source for a Young's double-slit experiment. Which of the following changes would cause the interference pattern to be more closely spaced?

A. Use slits that are closer together

B. Use a light source of lower intensity

C. Use a light source of higher intensity

D. Use a blue filter instead of a yellow filter

73] If two light waves are coherent:

- A. their amplitudes are the same
- B. their frequencies are the same
- C. their wavelengths are the same
- D. their phase difference is constant

74] In the equation $\sin \theta = \lambda/a$ for single-slit diffraction, θ is:

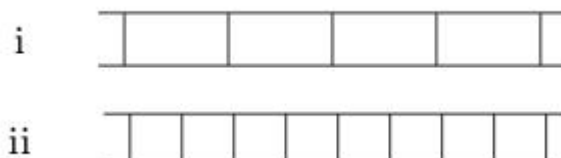
- A. the angle to the first minimum
- B. the angle to the second maximum
- C. the phase angle between the extreme rays
- D. $N\pi$ where N is an integer

75] Figure (i) shows a double-slit pattern obtained using monochromatic light. Consider the following five possible changes in conditions:

- 1. decrease the frequency
- 2. increase the frequency
- 3. increase the width of each slit
- 4. increase the separation between the slits
- 5. decrease the separation between the slits

Which of the above would change Figure (i) into Figure (ii)?

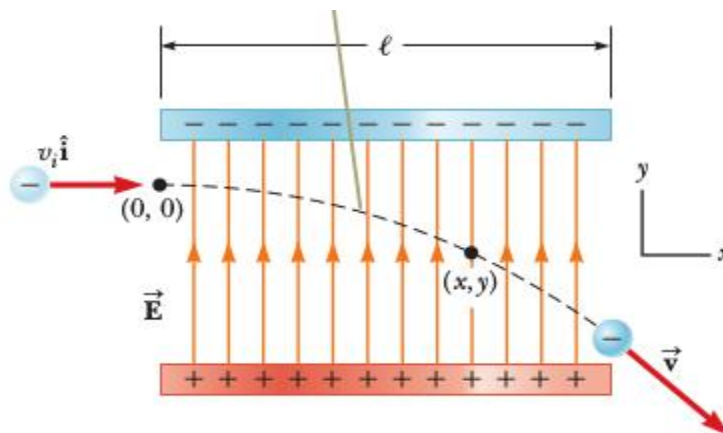
- A. 3 only
- B. 5 only
- C. 1 and 5 only
- D. 2 and 4 only



Electrostatics

76] A water droplet of mass 3.00×10^{-12} kg is located in the air near the ground during a stormy day. An atmospheric electric field of magnitude 6.00×10^3 N/C points vertically downward in the vicinity of the water droplet. The droplet remains suspended at rest in the air. What is the electric charge on the droplet?

77] An electron enters the region of a uniform electric field as shown in Figure below, with $v_i = 3.00 \times 10^6$ m/s and $E = 200$ N/C. The horizontal length of the plates is $l = 0.100$ m. Find the acceleration of the electron while it is in the electric field.

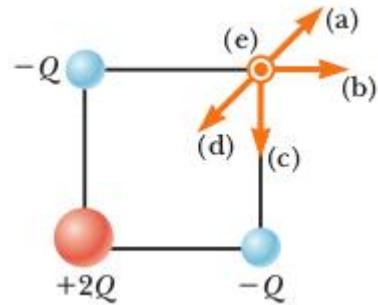


78] Two point charges attract each other with an electric force of magnitude F . If the charge on one of the particles is reduced to one-third its original value and the distance between the particles is doubled, what is the resulting magnitude of the electric force between them?

- A. $1/12 F$
- B. $1/6 F$
- C. $1/3 F$
- D. $3/4 F$

- 79] Three charged particles are arranged on corners of a square as shown in Figure below, with charge $-Q$ on both the particle at the upper left corner and the particle at the lower right corner and with charge $+2Q$ on the particle at the lower left corner. What is the direction of the electric field at the upper right corner, which is a point in empty space?

- A. It is upward and to the right.
- B. It is straight to the right.
- C. It is straight downward.
- D. It is downward and to the left.

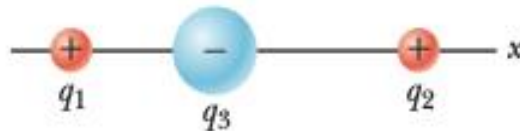


- 80] An object with negative charge is placed in a region of space where the electric field is directed vertically upward. What is the direction of the electric force exerted on this charge?

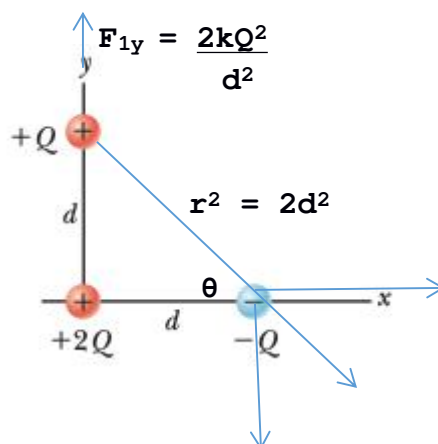
- A. It is up.
- B. It is down.
- C. There is no force.
- D. The force can be in any direction.

- 81] Assume the charged objects in Figure shown below are fixed. Notice that there is no sight line from the location of q_2 to the location of q_1 . If you were at q_1 , you would be unable to see q_2 because it is behind q_3 . How would you calculate the electric force exerted on the object with charge q_1 ?

- A. Find only the force exerted by q_2 on charge q_1 .
- B. Find only the force exerted by q_3 on charge q_1 .
- C. Add the force that q_2 would exert by itself on charge q_1 to the force that q_3 would exert by itself on charge q_1 .
- D. Add the force that q_3 would exert by itself to a certain fraction of the force that q_2 would exert by itself.



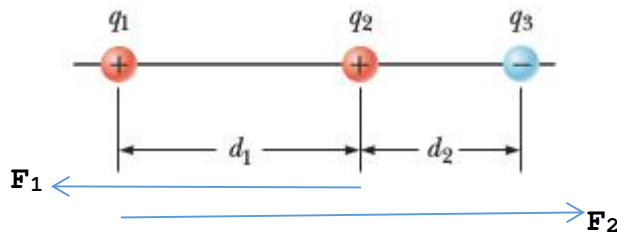
- 82] A point charge $+2Q$ is at the origin and a point charge $-Q$ is located along the x axis at $x = d$ as in Figure shown below. Find a symbolic expression for the net force on a third point charge $+Q$ located along the y axis at $y = d$.



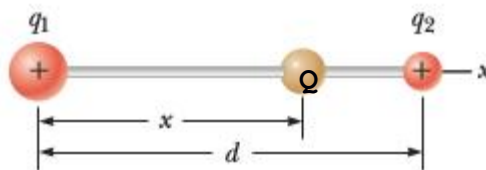
$$\cos(\theta) = d/2d^2 = 1/2d$$

$$\sin(\theta) = d/2d^2 = 1/2d$$

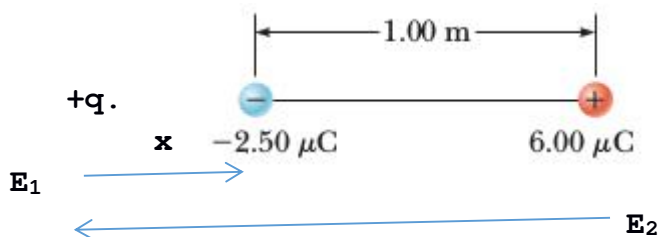
- 83] Three point charges lie along a straight line as shown in Figure below, where $q_1 = 6.00 \text{ mC}$, $q_2 = 1.50 \text{ mC}$, and $q_3 = -2.00 \text{ mC}$. The separation distances are $d_1 = 4.00 \text{ cm}$ and $d_2 = 2.00 \text{ cm}$. Calculate the magnitude of the net electric force on q_1 .



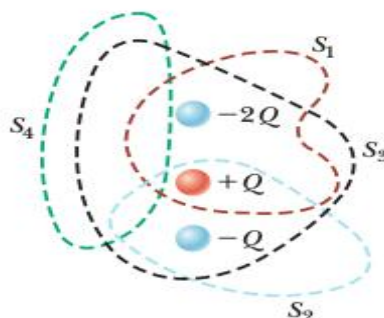
- 84] Two small beads having positive charges $q_1 = 4q$ and $q_2 = q$ are fixed at the opposite ends of a horizontal insulating rod of length $d = 1.50 \text{ m}$. The bead with charge q_1 is at the origin. As shown in Figure below, a third small, charged bead is free to slide on the rod. At what position x is the third bead in equilibrium?



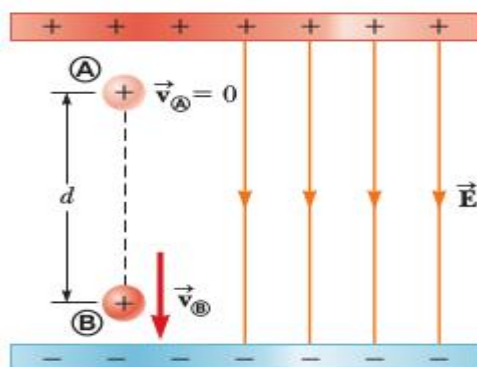
- 85] In Figure shown below, determine the point (other than infinity) at which the electric field is zero.



- 86] A proton is projected in the positive x direction into a region of a uniform electric field $E = (-6.00 \times 10^5 \text{ i}) \text{ N/C}$ at $t = 0$. The proton travels 7.00 cm as it comes to rest. Determine:
- the acceleration of the proton,
 - its initial speed, and
 - the time interval over which the proton comes to rest.
- 87] A flat surface of area 3 m^2 is rotated in a uniform electric field of magnitude $E = 6 \times 10^5 \text{ N/C}$. Determine the electric flux through this area:
- when the electric field is perpendicular to the surface and
 - when the electric field is parallel to the surface.
- 88] Four closed surfaces, S_1 through S_4 , together with the charges $-2Q$, Q , and $2Q$ are sketched in Figure shown below. (The colored lines are the intersections of the surfaces with the page.) Find the electric flux through each surface.

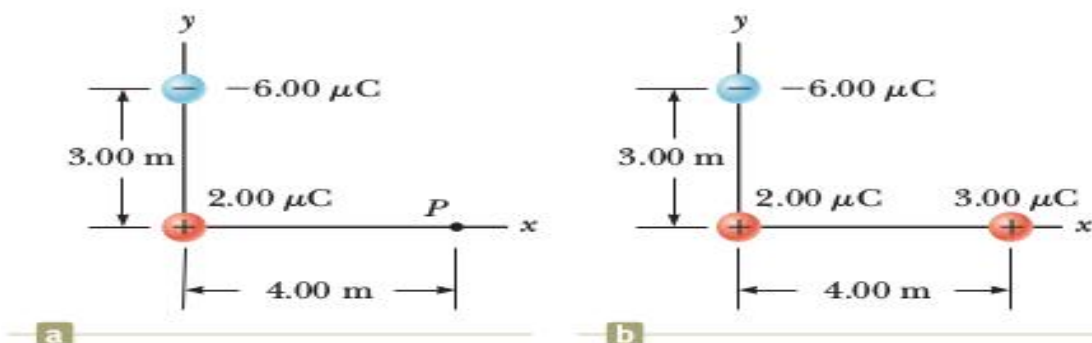


- 89] A proton is released from rest at point A in a uniform electric field that has a magnitude of $8.0 \times 10^4 \text{ V/m}$ (see Fig. Shown below). The proton undergoes a displacement of magnitude $d = 0.50 \text{ m}$ to point B in the direction of $\vec{E}$. Find the speed of the proton after completing the displacement.

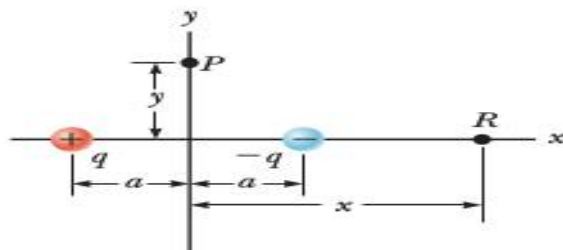


- 90] As shown in Figure shown below a, a charge $q_1 = 2.00 \text{ mC}$ is located at the origin and a charge $q_2 = 26.00 \text{ mC}$ is located at $(0, 3.00) \text{ m}$.

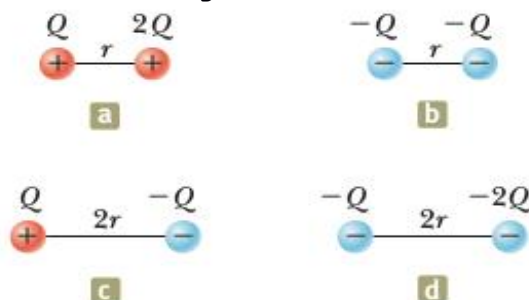
- (A) Find the total electric potential due to these charges at the point P, whose coordinates are $(4.00, 0) \text{ m}$.
 (B) Find the change in potential energy of the system of two charges plus a third charge $q_3 = 3.00 \text{ mC}$ as the latter charge moves from infinity to point P (see Fig. shown below b).



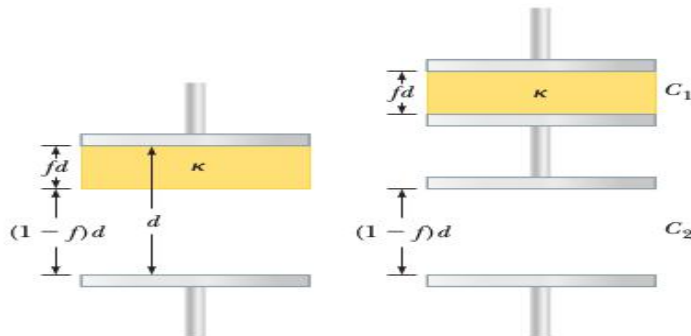
- 91] An electric dipole consists of two charges of equal magnitude and opposite sign separated by a distance $2a$ as shown in Figure shown below. The dipole is along the x axis and is centered at the origin.
 (A) Calculate the electric potential at point P on the y axis.
 (B) Calculate the electric potential at point R on the positive x axis.
 (C) Calculate V and E_x at a point on the x axis far from the dipole.



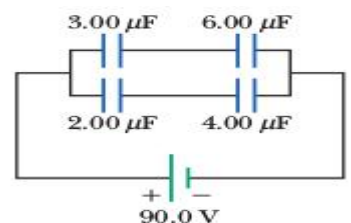
- 92] Rank the potential energies of the four systems of particles shown in Figure shown below from largest to smallest. Include equalities if appropriate.



- 93] The electric potential at $x = 3.00$ m is 120 V, and the electric potential at $x = 5.00$ m is 190 V. What is the x component of the electric field in this region, assuming the field is uniform?
- 94] A proton is released from rest at the origin in a uniform electric field in the positive x direction with magnitude 850 N/C. What is the change in the electric potential energy of the proton-field system when the proton travels to $x = 2.50$ m?
- 95] An electron in an x-ray machine is accelerated through a potential difference of 1.00×10^4 V before it hits the target. What is the kinetic energy of the electron in electron volts?
- 96] A parallel-plate capacitor with a plate separation d has a capacitance C_0 in the absence of a dielectric. What is the capacitance when a slab of dielectric material of dielectric constant k and thickness fd is inserted between the plates (see Fig. Shown below), where f is a fraction between 0 and 1?



- 97] A parallel-plate capacitor is connected to a battery. What happens to the stored energy if the plate separation is doubled while the capacitor remains connected to the battery?
- (a) It remains the same. (b) It is doubled.
 (c) It decreases by a factor of 2. (d) It decreases by a factor of 4.
 (e) It increases by a factor of 4.
- 98] When a potential difference of 150 V is applied to the plates of a parallel-plate capacitor, the plates carry a surface charge density of 30.0 nC/cm². What is the spacing between the plates?
- 99] For the system of four capacitors shown in Figure below, find
- (a) the equivalent capacitance of the system,
 (b) the charge on each capacitor, and
 (c) the potential difference across each capacitor.
 (d) the total energy stored in the circuit.
 (e) the energy stored in each capacitor.



- 100] A small, rigid object carries positive and negative 3.50 nC charges. It is oriented so that the positive charge has coordinates (21 mm, 1 mm) and the negative charge is at the point (1.5 mm, 21.5 mm).
- (a) Find the electric dipole moment of the object. The object is placed in an electric field $\mathbf{E} = (8 \times 10^3 \mathbf{i} + 5 \times 10^3 \mathbf{j})$ N/C.
- (b) Find the torque acting on the object.
- (c) Find the potential energy of the object-field system when the object is in this orientation.