$\sigma = E\varepsilon$ $\sigma = F/A$ $\varepsilon = (L-L_0)/L_0$ $p = F/A$; $p_h = \rho gh$; 1 atm = 1.013×10^5 Pa, $F_B = \rho gV$

$A_1v_1 = A_2v_2$ Av -volume flow rate, Mass flow rate = $Av\rho$

$p_1 + 1/2\rho v_1^2 + \rho gh_1 = p_2 + 1/2\rho v_2^2 + \rho gh_2$ flow in horizontal pipe: $p_1 + 1/2\rho v_1^2 = p_2 + 1/2\rho v_2^2$

$T(^0C) = \frac{5}{9}[T(^0F) - 32]$; $T(^0F) = \frac{9}{5}T(^0C) + 32$; $T(K) = [T(^0C) + 273]$

$L - L_0 = \alpha L_0 (T-T_0)$; $A - A_0 = 2\alpha L_0 (T-T_0)$; $V - V_0 = \beta V_0 (T-T_0)$ $V - V_0 = 3\alpha V_0 (T-T_0$ $\sigma = Y\alpha (T-T_0)$

ideal gas: $PV = nRT$ T- in kelvins, $N_{Av} = 6.02 \times 10^{23}$ /mole $N = nN_{av}$ $R = 8.313$ J/mol·K

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$; P – absolute $\rho = \frac{m}{V}$ $n = \frac{\text{mass}}{\text{molecular} - \text{mass}}$ Heat: $Q = mc(T - T_0)$, $Q = mL_F$

L - latent heat heat lost = heat gained $c_{water} = 4186 \frac{J}{kg.^0C}$; $L_F = 3.35 \times 10^5 \frac{J}{kg}$; $c_{ice} = 2100 \frac{J}{kg.^0C}$

$Q = kA\frac{T_1 - T_2}{L}t$ $Q = \varepsilon\sigma A(T^4 - T_0^4)t$ $\sigma = 5.67 \times 10^{-8}$ W/m^{2}K^4 Thermodynamics: $\Delta U = Q - W$ $W = P\Delta V$

$Q_h = W + Q_c$ $e = \frac{W}{Q_h}$ $e = 1 - \frac{T_c}{T_h}$ $COP = \frac{Q_c}{W}$ $COP = \frac{T_c}{T_h - T_c}$

$x = A\cos(\omega t)$ $v = -\omega A\sin(\omega t)$ $\omega = 2\pi f = \frac{2\pi}{T}$ $F = kx$ period: $T_{spring} = 2\pi\sqrt{\frac{m}{k}}$; $T_{pend} = 2\pi\sqrt{\frac{L}{g}}$

$\omega = \sqrt{\frac{k}{m}}$ $f = \frac{1}{T}$ $v_{max} = A\omega$ $E = \frac{1}{2}mv^2 + \frac{1}{2}kx^2$; $E = \frac{1}{2}kA^2$; $v = \lambda f$; $f = 1/T$

linear mass: $\mu = \frac{m}{L}$; $v = \sqrt{\frac{F}{\mu}}$ sound: $v = 343$ m/s $I_0 = 10^{-12}$ W/m^2 $I = \frac{P}{4\pi R^2}$

$v = 331 \text{ m/s}\sqrt{\frac{T}{273K}}$ $\beta = 10\text{dB}\log\frac{I}{I_0}$ $\beta_2 - \beta_1 = 10\text{dB}\log\frac{I_2}{I_1}$ $f = f_0\frac{343\text{m/s} \pm v_0}{343\text{ m/s} \mp v_s}$

standing waves on string and in open pipe: $n = 1, 2, 3.$, $f = \frac{v}{2L}n$ $\lambda = \frac{2L}{n}$ closed pipe: n = 1, 3, 5,.

$f = \frac{v}{4L}n$ $\lambda = \frac{4L}{n}$ Electric charge: $q = Ne$ $F = k\frac{q_1q_2}{r^2}$ $E = k\frac{q}{r^2}$ $F = qE$ $qE = ma$ $q\Delta V + \Delta K = 0$

$K = \frac{1}{2}mv^2$ $\Delta V = E$ $k = 8.99 \times 10^9$ Nm^2/C^2 $e = 1.6 \times 10^{-19}$ C $m_e = 9.11 \times 10^{-31}$ kg Circuits: $V = I*R$

$I = \frac{\Delta q}{\Delta t} = \frac{Ne}{t}$; $P = \frac{E}{\Delta t}$ $P = I^2R$ $P = \frac{V^2}{R}$ $P = I*V$; $V = V_m\sin\omega t$ $V_{rms} = \frac{V_m}{\sqrt{2}}$ $I_{rms} = \frac{I_m}{\sqrt{2}}$

in series : $R_{eq} = R_1 + R_2 + \ldots + R_n$ in parallel: $R_{eqv} = (\frac{1}{R_1} + \frac{1}{R_2})^{-1}$

$P_{avg} = \frac{1}{2}V_mI_m$ $P_{avg} = V_{rms}I_{rms}$ $P_{avg} = \frac{V_{rms}^2}{R}$ $P_{avg} = I_{rms}^2R$ Light: $n = \frac{c}{v}$ $\lambda = \lambda_0/n$ $c = 3$

$\times 10^8$ m/s $n_1\sin\theta_1 = n_2\sin\theta_2$ $n_1\sin\theta_{cr} = n_2\sin 90^0$ mirror and lens equation $\frac{1}{f} = \frac{1}{do} + \frac{1}{d_i}$

$m = \frac{h_i}{h_o} = -\frac{d_i}{do}$ light interfernce: $d\sin\theta = m\lambda$; $\tan\theta = \frac{y}{D}$ $y = D(m\lambda/d)$

1. How large a force is necessary to stretch a 2.0-mm-diameter steel wire ($E = 2.0 \times 10^{11}$ N/m^2) by 1.0%?

a. 3.1×10^3 N
b. 6.3×10^3 N
c. 9.4×10^3 N
d. 1.3×10^4 N
e. 3.1×10^7 N

2 Crew members attempt to escape from a damaged submarine 80 m below the surface. What force must they apply to a pop-out hatch of radius of 18 cm to push it out? Assume the density of ocean water 1025 kg/m^3.

A) 82 kN
B) 124 kN
C) 165 kN
D) 186 kN
E) 252 kN

3 A block of wood has density 0.50 g/cm^3 and mass 1 500 g. It floats in a container of oil (the oil's density is 0.75 g/cm^3). What volume of oil does the wood displace?

A) 3 000 cm^3
B) 2 000 cm^3
C) 1 500 cm^3
D). 1 000 cm^3
E) 500 cm^3

4. A sample of unknown material appears to weigh 300 N in air and 200 N when immersed in water. The density of the material is closest to

A) 1200 kg/m^3
B) 2000 kg/m^3
C) 3000 kg/m^3
D) 4000 kg/m^3
E) 6500 kg/m^3

5. A aluminum spherical ball of radius 22 cm and density of 2700 kg/m^3 is supported by a string while submerged in water. What is the tension in the string ?
A) 743 N
B) 437 N
C) 1180 N
D) 128 N
E) 25 N

6. A water hose of radius of 1.2 cm is used to fill a bucket of volume of 75 L. If it takes 2.2 min to fill the bucket, what is the speed at which the water leaves the hose?

A) 0.5 m/s
B) 1.3 m/s
C) 3.0 m/s
D) 4.9 m/s
E) 8.8 m/s

7. If wind (density of air =1.29 kg/m^3) blows at 30 m/s parallel to a flat roof having an area of 475 m^2, what is the force exerted on the roof?

A) 2.76×10^5 N, up
B) 8.75×10^5 N, down
C) 4.26×10^6 N, up
D) 6.16×10^6 N, down
E) 1.23×10^7 N, up

8. Water flows through a horizontal pipe of cross-sectional area 10.0 cm^2 at a gauge pressure of 2.5×10^4 Pa with a speed of 1.00 m/s. At a valve, the effective cross-sectional area of the pipe is reduced to 5.00 cm^2. What is the pressure at the valve? The density of water is 1000 kg/m^3
A) 0.110 atm
B) 0.235 atm
C) 0.200 atm
D) 0.157 atm
E) 7700 Pa

9. The temperature of the iron cube, 5 cm on edge, should be changed by what amount for the volume of the cube to increase by 0.35 cm^3. (The coefficient of linear expansion of iron is 1.2×10^{-5} per ^{0}C)

A) 55^0C
B) 167^0C
C) 77^0C
D) 355^0C
E) 431^0C

10. For mercury to expand from 4.0 cm^3 to 4.08 cm^3 , what change in temperature is necessary? ($\beta = 180 \times 10^{-6}/^0$C).

A) 400^0C
B) 267^0C
C) 111^0C
D) 8.2^0C
E) 5.5^0C

11. Suppose the ends of a 20-m-long steel beam are rigidly clamped at 0°C to prevent expansion. The rail has a cross-sectional area of 30 cm^2. What force does the beam exert when it is heated to 40°C? ($\alpha_{steel} = 1.1 \times 10^{-5}$/C°, $Y_{steel} = 2.0 \times 10^{11}$ N/m^2).

A) 2.6×10^5 N
B) 5.6×10^4 N
C) 1.3×10^3 N
D) 6.5×10^2 N
E) 6.5×10^7 N

12. Approximately how many moles of argon (atomic mass is 18g/mol) are needed to fill the space between two panes of glass in a window, if the absolute gas pressure is 2 atm., the volume of the space is 0.2 m^3 , and the temperature is 30^0C? (1atm=1.013x10^5Pa) What is the mass of the argon inside?
A) 125 g
B) 288 g
C) 421 g
D) 864 g
E) Can't tell.

13. A helium-filled balloon has a volume of 1 m^3. As it rises in the earth's atmosphere, its volume expands. What will its new volume be (in m^3) if its original temperature and pressure are 20° C and 1 atm, and its final temperature and pressure are -40° C and 0.1 atm?
A) 1
B) 6
C) 8
D) 10
E) 1.5

14 A scuba diver has his lungs filled to half capacity (3 liters) when 10 m below the surface. If the diver holds his breath while quietly rising to the surface, what will the volume of the lungs be (in liters) at the surface? Assume the temperature is the same at all depths. (The density of water is 1.0 x 10^3 kg/m^3.)
A) 5.9
B) 4.5
C) 6.4
D) 3.9
E) 3.1

15. An 500 g aluminum electric tea kettle has a 500-W heating coil. How long will it take to heat up 1 kg of water from 18ºC to 98ºC in this kettle? The specific heat of aluminum is 900 J/kg·ºC and the specific heat of water is 4186 J/kg·ºC

A) 2 minutes
B) 7 minutes
C) 12 minutes
D) 22 minutes
E) 29 minutes

16. A 120 grams of ice at temperature 0^0C added to water was able to decrease the temperature of water from 26^0C to 11^0C. What was the mass of the water? (latent heat of fusion for water is 335000 J/kg; specific heat of water is 4186 J/kg^{0}C) .

A) 128 g
B) 236 g
C) 349 g
D) 728 g
E) 891 g

17. How much heat must be added to 0.05 kg of copper at 25^0C to melt it completely? C_{cu} = 387 J/kg. L_f = $20.7x10^4$ J/kg, melting point T = 1083 ^{0}C

A) 5 kJ
B) 12 kJ
C) 25 kJ
D) 0.5 kJ
E) 31 kJ

18. A water heater is operated by a solar power. If the solar collector has an area of 6 m^2, and the intensity delivered by sunlight is 550 W/m^2, how long does it take to increase the temperature of 1000 kg of water from 20^0C to 60 ^{0}C?

A) 0.55 h
B) 2.00 h
C) 7.50 h
D) 14.0 h
E) 21.0 h

19. How long will it take to transfer 5.5 MJ of heat through a 2.25 m^2 pane of 3 mm thick glass (k=0.84 J/sm^0 C) if the temperature difference is 12^0 C.

A) 208 hr
B) 20.8 hr
C) 12.1 min
D) 75 s
E) 15 s

20 A radiator has an emissivity of 0.7 and its exposed area is 1.2 m^2. The temperature of the radiator is 85^0C and the surrounding temperature is 20^0C. What is the net heat flow rate from the radiator? (σ = $5.67x10^{-8}$ W/m^2K^4)

A) 855 W
B) 628 W
C) 431 W
D) 325W
E) 100 W

21. Gas in a container expands at a constant pressure of 3 atm. Find the work done (in J) by the gas if the initial volume is 5 liters and the final volume is 10 liters.. (1 atm = 1.013×10^5 Pa, 1L = 0.001 m^3)
A) 0
B) 150
C) 15
D) 1 500
E) 1.5

22. A Carnot engine takes 2000 J from a hot reservoir at 500 K, does some work, and discards some heat to cold reservoir at 350 K. The work done by the engine is closest to

A) 3600 J
B) 3000 J
C) 2400 J
D) 1200 J
E) 600 J

23. A refrigerator has a coefficient of performance of 4.0. When removing 2.4×10^4 J from inside the refrigerator, how much energy is sent into the environment?

A) 9.6×10^4 J
B) 3.0×10^4 J
C) 1.8×10^4 J
D) 0.60×10^4 J
E) 0.20×10^3 J

22. A mass of 0.40 kg, hanging from a spring with a spring constant of 80 N/m, is set into an up-and-down simple harmonic motion. What is the speed of the mass when moving through the equilibrium point? The starting displacement from equilibrium is 0.10 m.

A) zero
B) 1.4 m/s
C) 2.0 m/s
D) 3.4 m/s
E) 6.5 m/s

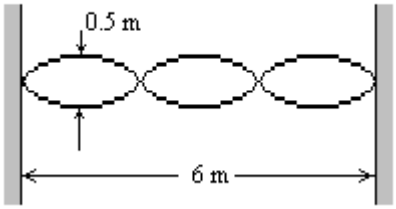
23. A 0.3-kg block, attached to a spring, executes simple harmonic motion according to x = 0.8 cos (35 rad/s·t), where x is in meters and t is in seconds. Find the spring constant of the spring.

A) 22 N/m
B) 1500 N/m
C) 368 N/m
D) 160 N/m
E) 2.8 N/ m

24. A string of linear mass 0.0015 kg/m is under a tension of 40 N. What should its length be if the frequency of the second harmonic is 440 Hz?

A) 0.26 m
B) 0.37 m
C) 0.41 m
D) 0.85 m
E) 1.5 m

25. A standing wave of frequency 45 Hz is set up on a string 6 m long as shown. What is the speed at which wave propagates on the string?



A) 25 m/s
B) 45 m/s
C) 100 m/s
D) 180 m/s
E) 220 m/s

26. The intensity at a distance of 4.0 m from a source that is radiating equally in all directions is 9.85×10^{-7} W/ m^2. What is the intensity level in dB at a distance of 6 m?

A) 17.8 dB
B) 20.0 dB
C) 26.5 dB
D) 32.2 dB
E) 56.4 dB

27. The intensity of a certain sound wave is 2×10^{-7} W/m^2. If its intensity is raised by 30 decibels, what is the new intensity in W/m^2?

A) 6×10^{-5} W/m^2
B) 5×10^{-4} W/m^2
C) 2×10^{-4} W/m^2
D) 6×10^{-3} W/m^2
E) 2×10^{-2} W/m^2

28. A 500-Hz whistle is moved toward a listener at a speed of 10.0 m/s. At the same time, the listener moves at a speed of 20.0 m/s in a direction away from the whistle. What is the apparent frequency heard by the listener? (The speed of sound is 340 m/s.)
A) 463 Hz
B) 485 Hz
C) 533 Hz
D)547 Hz
E) 562 Hz

29. An organ pipe, open at both ends, is 2.2 m long. If the velocity of sound in air is 343 m/s, the frequency of third harmonic of this pipe is:

A) 116 Hz
B) 234 Hz
C) 366 Hz
D) 499 Hz
E) 5640 Hz

30. A 2 mg particle carrying a charge of 4nC is placed in an uniform electric field of magnitude of 100 N/C. Find the particle's acceleration.

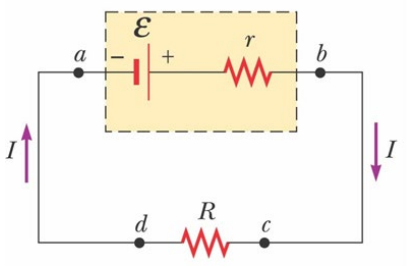
A.) 0.2 m/s^2
B.) 0.85 m/s^2
C.) 7.2 m/s^2
D.) 80.0 m/s^2
E.) 0.0025 m/s^2

31. What diameter must a copper wire ($\rho = 1.68 \times 10^{-8}$ Ωm) be if it is to carry a maximum current of 30 A and produce no more than 1.6 W of heat per meter of length?

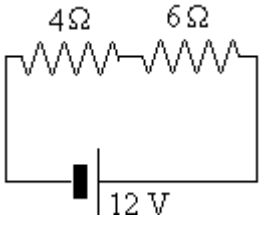
A) 0.025 mm
B) 0.44 mm
C) 3.5 mm
D) 8.4 mm
E) 2.2 cm

32. If the terminal voltage of the 9- V battery connected across 10- Ω resistor R is 8.4 V, what is the internal resistance of the battery?

A) 0. 9 Ω
B) 8.0 Ω
C) 0.70 Ω
D) 6.4 Ω
E) 0.25 Ω

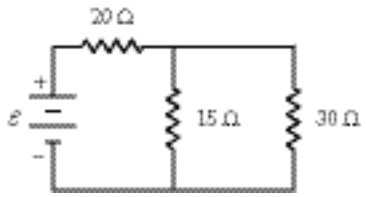


33. The power dissipated in the 6 □ resistor is:



A)2.25W
B)8.64W
C)9.56W
D)12.5W
E)24.0W

34. What is the current in the 15-Ω resistor when emf = 9.0 V?



A) 0.20 A
B) 0.30 A
C) 0.10 A
D) 0.26 A
E) 0.60 A

35. The current in a wire is $I = 15x10^{-3}A$. How many electrons will pass a point in this wire in 4 min? ($e = 1.6x10^{-19}C$)

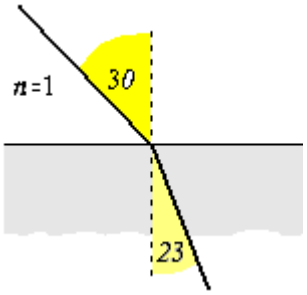
A) $8 \cdot 10^{14}$
B) $5.4 \cdot 10^{16}$
C) $1.22 \cdot 10^{15}$
D) $2.25 \cdot 10^{19}$
E) None

36. A slab made of glass (n= 1.5) has a thickness of 5 m. How long does it take light to pass perpendicularly through the slab?
A) 2 ns
B) 12 ns
C) 25 ms
D) 25 ns

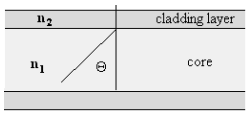
E) 125 s

37. Light enters a substance from air at 30.0^0C to the normal. It continues through the substance at 23.0^0 to the normal. What would be the critical angle for this substance?

A) 63.9^0
B) 51.4^0
C) 36.7^0
D) 12.6^0
E) 16.6^0



38. An optical fiber consists of a core made of glass of $n_1 = 1.68$ surrounded by a cladding made layer of plastics with index of refraction $n_2 = 1.42$. The critical angle θ_c for the interface between the glass and the plastics is closest to



A) 58.0^0
B) 42.0^0
C) 36.5^0
D) 22.0^0
E) 16.3^0

39. A 1.5 cm high object is placed 20 cm from the concave mirror with radius of curvature 30 cm. Determine the position of the image and its magnification
A) 60 cm, -3
B) 60 cm , 3
C) 30 cm, 2
D) 15 cm, -5
E) 30 cm, -2

40. A 8-cm tall object is placed 40 cm away from a converging lens of a focal length 30 cm. What is the nature and location of the image?

A) The image is real, 2.5 cm tall, 60 cm on the same side as object.
B) The image is virtual, 2.5 cm tall, 60 cm on the other side of the lens.
C) The image is virtual, 24 cm tall, 120 cm on the same side as object.
D) The image is real, 24 cm tall, 120 cm on the other side of the lens.

E) none of the above.

41. An object 50-cm high is placed 1.0 m in front of a converging lens whose focal length is 1.5 m. Determine the image height (in cm).

a. 77
b. 150
c. 52
d. 17
e. 83

43. Light of wavelength 475 nm falls on a double-slit grating with slit separation of 0.01 mm. What is the angular position of the second order bright fringe?

A) 0.45^0
B) 8.6^0
C) 15.1^0
D) 2.4^0
E) 5.45^0 cm

44. A diffraction grating produces a first-order bright fringe that is 0.18 m away from the central bright fringe on a flat screen. The separation between the slits of the grating is 2.5×10^{-6} m, and the distance between the grating and the screen is 0.8 m. What is the wavelength of the light shining on the grating?

A) 345 nm
B) 490 nm
C)550 nm
D) 620 nm
E) 760 nm