FINAL EXAM **PHYSICS 103** **FALL 2004** **A**

$\rho = \frac{m}{V}$; $p = \frac{F}{A}$; $p_h = \rho g h$; 1 atm = 1.013 x10^5 Pa, $F_B = \rho g V_{im}$, $A_1 v_1 = A_2 v_2$

Av -volume flow rate $p_1 + ½\rho v_1^2 + \rho g h_1 = p_2 + ½\rho v_2^2 + \rho g h_2$ flow in horizontal pipe: $p_1 + ½\rho v_1^2 = p_2 + ½\rho v_2^2$

$T(^0C) = \frac{5}{9}[T(^0F) - 32]$; $T(^0F) = \frac{9}{5}T(^0C) + 32$; $T(K) = [T(^0C) + 273]$; 1 m = 100 cm = 1000 mm

$L - L_0 = \alpha L_0 (T-T_0)$ $\sigma = Y\alpha (T-T_0)$ $V - V_0 = \beta V_0 (T-T_0)$; 1 Liter = 10^{-3} m^3 $V_{cube} = a^3$ $A_{circle} = \pi r^2$

Heat: $Q = mc(T - T_0)$, $Q = mL$, c - specific heat L - latent heat heat lost = heat gained

$c_{water} = 4186 \frac{J}{kg \cdot {}^0 C}$; $L_F = 3.33x10^5 \frac{J}{kg}$; $c_{ice} = 2100 \frac{J}{kg \cdot {}^0 C}$

1 hr = 3600 s $\sigma = 5.67x10^{-8}$ W/m^{2}K^4 R = 8.313 J/mol·K; $Q = kA\frac{T_1 - T_2}{L}t$

$\frac{\Delta Q}{\Delta t} = e\sigma A T_1^4$ $\frac{\Delta Q}{\Delta t} = e\sigma A(T_1^4 - T_2^4)$ $n = \frac{mass}{molecular - mass}$

PV = nRT $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$; $N_{av} = 6.02x10^{23}$/mol T - temp. in kelvins, $\rho = \frac{m}{V}$,

$x = A\cos(\omega t)$ $v = -\omega A\sin(\omega t)$ $\omega = 2\pi f = \frac{2\pi}{T}$ F = kx period: $T_{spring} = 2\pi\sqrt{\frac{m}{k}}$; $f = \frac{1}{T}$

$\omega = \sqrt{\frac{k}{m}}$ $v_{max} = A\omega$ $E = ½ mv^2 + ½ kx^2$; $E = ½ kA^2$; $E = ½ m(v_m)^2$ waves: $v = \lambda f$;

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

$I = \frac{P}{A} = \frac{P}{4\pi r^2}$ $\beta = 10dB\log\frac{I}{I_0}$ $\beta_2 - \beta_1 = 10dB\log\frac{I_2}{I_1}$ $f = f_0\frac{343m/s \pm v_D}{343m/s \pm v_S}$

standing waves n = 1, 2, 3 ……. , closed pipe: n = 1, 3, 5, …

$\lambda = \frac{2L}{n}$ $f = \frac{v}{2L}n$ open : $\lambda = \frac{2L}{n}$ $f = \frac{v}{2L}n$ closed : $\lambda = \frac{4L}{n}$ $f = \frac{v}{4L}n$

Light: $n = \frac{c}{v}$ $\lambda = \lambda_0/n$ c = 3 x10^8 m/s $n_1\sin\theta_1 = n_2\sin\theta_2$ $n_1\sin\theta_{cr} = n_2\sin 90^0$ $d\sin\theta = m\lambda$; $y = D\frac{m\lambda}{d}$

Electric Current: $R = \rho\frac{L}{A}$; $R = R_0[1 + \alpha(T - T_0)]$; V = I*R; $P = \frac{E}{\Delta t}$ $I = \frac{\Delta Q}{\Delta t} = \frac{Ne}{t}$; e = 1.6 x 10^{-19} C

$P = I^2R = \frac{V^2}{R} = I*V$; $V = V_0\sin(2\pi ft)$; $V_{rms} = \frac{V_0}{\sqrt{2}}$ $I_{rms} = \frac{I_0}{\sqrt{2}}$ $I_{rms} = \frac{V_{rms}}{R}$ $P_{av} = V_{rms}*I_{rms} = I_{rms}^2R = \frac{V_{rms}^2}{R}$

1. A vertical spring stretches 6 cm when a 18-kg block is hung from its end. What is the spring constant of this spring?
A) 2 N/m
B) 196 N/m
C) 690 N/m
D) 1470 N/m
E) 2940 N/m

Mg = kx; k=Mg/x=18*9.8/0.06=

2. A 3-kg block, attached to a spring, executes simple harmonic motion according to x = 2 cos (30 rad/s·t), where x is in meters and t is in seconds. The period of oscillation of the spring is:
A) 0.2 s
B) 0.4 s
C) 0.6 s
D) 0.8 s
E) 1.8 s

$\omega = 2\pi f = \frac{2\pi}{T}$ T=2π/ω = 2*3.1415/30=

3. A 0.25 - kg block oscillates on the end of the spring with a spring constant of 1000 N/m. If the oscillation is started by elongating the spring 0.12 m, what is the maximum speed of the block?
A) 1.5 m/s
B) 3.5 m/s
C) 5.5 m/s
D) 7.6 m/s
E) 9.5 m/s

$\omega = \sqrt{\frac{k}{m}}$ v_{max} = Aω = 0.12*sqrt(1000/0.25)=0.12*sqrt(4000)=

4. A sinusoidal wave with the wavelength 1.2 m travels along a string. If the period of the wave is 0.48 s. What is the wave speed?

$v = \lambda f$ $\omega = 2\pi f = \frac{2\pi}{T}$

v=1.2/0.48=

A) 0.4 m/s
B) 0.9 m/s
C) 1.6 m/s
D) 2.5 m/s
E) 3.1 m/s

5. The intensity at a distance of 6.0 m from a source that is radiating equally in all directions is 9.85 x 10^{-9} W/ m^2 . What is the intensity level in dB?

$$\beta = 10dB\log\frac{I}{I_0} = 10dB\log(9.85\times10^{-9}/10^{-12}) =$$

$I_0 = 10^{-12}$ W/m^2

A) 17.0 dB
B) 20.0 dB
C) 26.0 dB
D) 32.0 dB
E) 40.0 dB

6. A stationary source emits sound with a frequency of 1250 Hz. If the speed of the sound is 343 m/s, what frequency is heard by an observer approaching the source with a speed of 25 m/s?

A) 1550 Hz
B) 1341 Hz
C) 1110 Hz
D) 890 Hz
E) 20 Hz

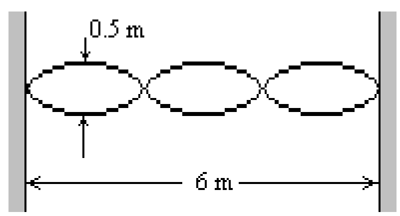
$$f = f_0 \frac{343\text{m}/\text{s} \pm v_D}{343\text{m}/\text{s} \pm v_S}$$

7. The fundamental frequency of a standing wave on a string of linear mass 0.004 kg/m and length 0.6 m when it is subjected to tension of 50.0 N is closest to:

$$v = \sqrt{\frac{F}{\mu}} \qquad f = \frac{v}{2L}n$$

A) 132 Hz
B) 93 Hz
C) 152 Hz
D) 365 Hz
E) none of above

8. A standing wave pattern is established in a string as shown. What is the wavelength of the standing wave?



A) 0.25 m
B) 0.5 m
C) 1.0 m
D) 2.0 m
E) 4.0 m

n=3

$$\lambda = \frac{2L}{n}$$

9. An organ pipe open at both ends has a length of 0.65 m. If the velocity of sound in air is 343 m/s, what is the frequency of the second harmonic?

$$f = \frac{v}{2L}n$$

A) 213 Hz
B) 425 Hz
C) 528 Hz
D) 650 Hz
E) 788 Hz

10. A weight of a solid object is 2.06 N when weighed in air and 1.76 N when weighed in a liquid of density 1200 kg/m^3. The density of the object is

mg - ρgV 1200*2.06/(2.06-1.76)=8240 kg/m3

A) 1200 kg/m^3
B) 3500 kg/m^3
C) 8240 kg/m^3
D) 14000 kg/m^3
E) 16500 kg/m^3

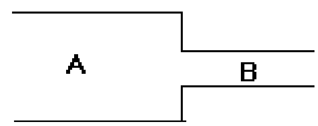
11. The hydraulic automobile jack illustrates:
A) Archimedes' principle
B) Newton's third law
C) Pascal's principle
D) Newton's second law
E) Hooke's law

12. A cylindrical window of radius of 15 cm in a submarine can withstand a maximum force of 5.2×10^5 N. What is the maximum depth in the ocean to which the submarine can go without damaging the window? ($\rho_w = 1000$ kg/m^3)

$P = Pa + \rho_w gh$ $F = P*A$

A) 680 m
B) 750 m
C) 1200 m
D) 1327 m
E) 2327 m

13. Water (density = 1000 kg/m^3) flows through a horizontal tapered pipe. At the wide end its speed is 4.0 m/s and at the narrow end it is 8.0 m/s. The pressure in the wide pipe is 2.5×10^5 Pa. The pressure in the narrow pipe is:



$p_1 + ½\rho v_1^2 = p_2 + ½\rho v_2^2$

A) 2.5×10^2 Pa
B) 3.4×10^3 Pa,
C) 4.5×10^3 Pa
D) 2.3×10^5 Pa
E) 8×10^5 Pa

14. A metal rod 40.0000 cm long at 20 °C is heated to 176 °F. The length of the rod is then measured to be 40.0265 cm. What is the coefficient of linear expansion of the metal?

$T(^0C) = \frac{5}{9}[T(^0F) - 32]$ $L - L_0 = \alpha L_0 (T-T_0)$ T-To = 60C

A) 1.1×10^{-5}/C°
B) 2.2×10^{-6}/C°
C) 4.4×10^{-5}/C°
D) 5.3×10^{-5}/C°
E) 7.1×10^{-6}/C°

15. The heat given off by 600 grams of an alloy as it cools from 185^{0}C to 55^{0}C raises the temperature of 350 grams of water (c = 4184 J/kgC^0) from 15^{0}C to 55^{0}C. What is the specific heat of the alloy?

$Q = mc(T - T_0)$, $Q_1=Q_2$ c - specific heat heat lost = heat gained

A) 964 J/kgC^0
B) 859 J/kgC^0
C) 610 J/kgC^0
D) 486 J/kgC^0
E) 258 J/kgC^0

16. The melting point of aluminum is 660^{0}C, the latent heat of fusion is 4×10^5 J/kg, and its specific heat is 900 J/kgC^0. How much heat must be added to 500 g of aluminum at 27^{0}C to completely melt it?

$Q = mc(T - T_0)$, $Q = mL$, c - specific heat L - latent heat heat lost = heat gained

A) 147 kJ
B) 395 kJ
C) 273 kJ
D) 485 kJ
E) 624 kJ

17. By what primary heat transfer mechanism does the sun warm the earth?
A) Radiation
B) Convection
C) Conduction
D) none of the above
E) vaporization

18. What is the outside temperature if 19.5 x10^6 J of heat is lost through a 4.0 m^2 pane of 3 mm thick glass (k = 0.84 W/m^0C) in one hour from a house kept at 20^0C?

$$Q = kA\frac{T_1 - T_2}{L}t$$ =0.84*4*dT*3600/0.003=19.5*10^6

A) 0^0C
B) 5^0C
C) 10^0C
D) 15^0C
E) 30^0C

19. A radiator has an emissivity of 0.7 and its exposed area is 1.2 m^2. The temperature of the radiator is 80^0C=(80+273K) and the surrounding temperature is 20^0C=(20+273)K. What is the heat flow rate from the radiator? (σ = 5.67x10^{-8} W/m^2K^4) 0.7*1.2*5.67x10^{-8}*(353^4-293^4)

$$\frac{\Delta Q}{\Delta t} = e\sigma A(T_1^4 - T_2^4)$$

A) 855 W
B) 628 W
C) 388 W
D) 125W
E) 10 W

20. Nitrogen (molecular mass = 28 g/mol) occupies a volume of 0.12 m^3 when its temperature is 20^0 C and its pressure is 2 atm = 2*10^5 [Pa]. Using R = 8.31 J/mol·K, calculate the number of grams of nitrogen.

M=m*P*V/(R*T[K])=28*0.12*2*10^5/(8.31*293)=276 (g)

A) 64 g
B) 107 g
C) 160 g
D) 280 g
E) 424 g

21. An ideal gas occupies 0.6 m^3 when its temperature is 20^0 C and its pressure is 1.5 atm. Its temperature is now raised to 100^0C and its volume increased to 1.2 m^3 . The new pressure is:

P1V1/T1 = P_2V2/T2; $P_2=P_1*(V_1/V_2)*(T_2[K]/T_1[K])$

A) 0.1 atm
B) 0.3 atm
C) 0.52 atm
D) 0.95 atm
E) 1.40 atm

22. The resistance of a 2 m wire of resistivity $1.76\text{x}10^{--6}\ \Omega\text{m}$ is 7 Ω. What is the radius of the wire?

$$R = \rho\frac{L}{A} \qquad A=3.1415926*r^2$$

A) 0.4 mm
B) 0.8 mm.
C) 1.2 mm
D) 1.4 mm
E) 1.6

23. The resistivity of 2.5 m long wire is $7\text{x}10^{-6}\ \Omega\text{m}$ and its cross sectional area is $2\text{x}10^{-6}\text{m}^2$. If the potential difference of 6 V is applied across the wire, what is the current in the wire?

$$R = \rho\frac{L}{A} \qquad i = V/R$$

A) 3.5 A
B) 2.3 A
C) 1.5 A
D) 0.7 A
E) 0.3 A

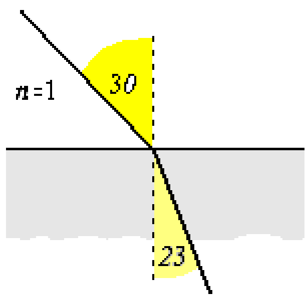
24. A 120-V voltage is applied across a resistor. If the power dissipated in this resistor is 5 W, what is the resistance of this resistor?
A) 1.25 kΩ
B) 2.88 kΩ
C) 4.15 kΩ
D) 5.21 kΩ
E) 8.69 kΩ

$$P = I^2R = \frac{V^2}{R} = I*V$$

25. An ac voltage of 8V·sin(377rad/s·t) is applied across a resistor of 3.5 Ω. What is the rms value of the current in this resistor?
A) 1.62 A
B) 1.12 A
C) 0.85 A
D) 0.05 A
E) 2.8 A

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

$n_1\sin\theta_1 = n_2\sin\theta_2$ n2=1.27 $n_1\sin\theta_{cr} = n_2\sin 90^0$



1.27*sin(cr.ang.)=1;   cr.ang. = $\sin^{-1}$[sin(23)/sin(30)]

A) 53^0
B) 51.4^0
C) 36.7^0
D) 12.6^0
E) 16.6^0

27. The critical angle of a certain piece of plastic in air is 37.3^0. What is the critical angle of the same plastic if it is immersed in water with refraction index of $n = 1.33$?

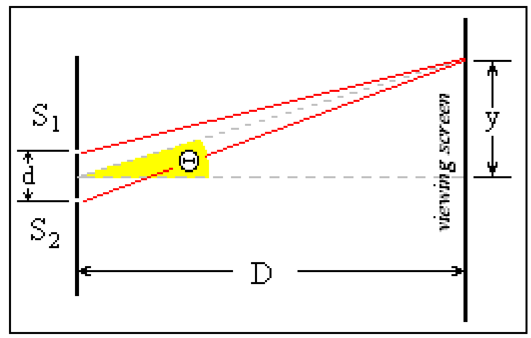
$n_1 \sin\theta_1 = n_2 \sin\theta_2$ $\quad$ $n_1 \sin\theta_{cr} = n_2 \sin 90^0$

A) 41.4^0
B) 48.4^0
C) 53.7^0
D) 63.0^0
E) 68.2^0

28. A 4-cm tall object is placed 60 cm away from a convex lens of a focal length 30 cm. What is the nature and location of the image? (see page 873)

A) The image is real, 2.5 cm tall, 30 cm on the same side as object.
B) The image is virtual, 2.5 cm tall, 30 cm on the other side of the lens.
C) The image is virtual, 4 cm tall, 60 cm on the same side as object.
D) The image is real, 4 cm tall, 60 cm on the other side of the lens.
E) none of the above.

29. Light of wavelength 575 nm falls on a double-slit grating with slit separation of 0.02 mm. The diffraction pattern is observed on the viewing screen 3 m away from the grating. What is the distance between adjacent bright fringes on the viewing screen?



A) 5.0 cm
B) 8.6 cm
C) 15.1 cm
D) 2.4 cm
E) 3.9 cm

$$\theta = \sin^{-1}\left(\frac{2\lambda}{d}\right)$$

$$d \sin\theta = m\lambda, \text{ for } m = 0, 1, 2, \ldots \quad \text{(maxima – bright fringes)}$$

30. A diffraction grating has 4000 lines per cm. The angle between the central maximum and the third order maximum is 36.0^0. What is the wavelength of the light?
A) 240 nm
B) 490 nm
C) 570 nm
D) 620 nm
E) 720 μm