Final for phy231, Tuesday December 12, 2000

Constants: g =9.8 m/s^2, k_B = 1.38 x 10^{-23} J/ ^{o}K
1 revolution = 2π radians = 360°
Moments of inertia: I(hoop)=MR^2, I(solid cylinder)=$\frac{1}{2}MR^2$, I(sphere)=$(2/5)MR^2$.

The four numbers correspond to forms A, B, C and D respectively.

(1,23,20,17) Three vectors of equal magnitude of 10 cm make angles of 0°, 180°, and 90° with respect to the x-axis. What is the length of the sum of these three vectors?

A) 0 cm
B) 10 cm
C) 20 cm
D) 30 cm
E) 40 cm

Answer: The two vectors at 0 and 180 cancel leaving one with a a length of 10 cm.

(2,24,21,18) A roller coaster with a mass of 1000 kg starts from rest at the top of a hill which is 100 m high. It coasts to the bottom of the hill, and then goes to the top of a second hill which is 60 m high. Use energy conservation to find the velocity at the top of the second hill. (There is no friction.)

A) 0 m/s
B) 28.0 m/s
C) 34.4 m/s
D) 44.3 m/s
E) 88.6 m/s

Answer: The kinetic energy at the top of the second hill ($\frac{1}{2}mv^2$) equals the change in potential energy (mgh where h=40 m). Solving for v gives 28.0 m/s.

(3,25,22,19) A car traveling at a speed of 14 m/s brakes to a stop over a distance of 20 m. How long does it take to stop? (Assume constant deceleration and no friction.)

A) 0.4 s
B) 0.7 s
C) 1.4 s
D) 2.5 s
E) 2.9 s

Answer: $x = \frac{1}{2}(v_o + v)t$ where $v = 0$, thus $t = 2.9$ s.

(4,1,23,20) A 0.05 kg arrow is fired horizontally. The bowstring exerts a force of 80 N on the arrow over a distance of 0.50 m. What is the speed of the arrow when it leaves the bow?

A) 40 m/s
B) 56.5 m/s
C) 28.5 m/s
D) 25 m/s
E) 60 m/s

Answer: Work done my the bow is $W = Fd = 40$ J. This goes into the kinetic energy of the arrow $KE = \frac{1}{2}mv^2 = W$. Solving for v gives 40 m/s.

(5,2,24,21) A person pushes on a block with force F as shown in the figure such that the block is moving at a constant speed of 2 m/s. The mass of the block is 10 kg, and the coefficient of kinetic friction between the block and floor is $\mu_k = 0.2$. How much work does it take to move the block a distance of 5 m?

A) Zero since there is no acceleration.
B) 20 J
C) 98 J
D) 490 J
E) 100 J

Answer: The frictional force is $F_f = \mu_k mg$=19.6 N. Since the velocity is constant $F = F_f$, and $W = Fd$=98 J.

(6,3,25,22) Two cars travel towards each other each with a speed of 20 m/s and collide head on and stick together. One has a mass of 2000 kg and the other has a mass of 3000 kg. What is the magnitude of the total momentum after the collision?

A) 1.0 x 10^4 kg m/s
B) 2.0 x 10^4 kg m/s
C) 3.0 x 10^4 kg m/s
D) 4.0 x 10^4 kg m/s
E) 5.0 x 10^4 kg m/s

Answer: The initial momentum is $m_1v_1 + m_2v_2$ = 2000x20 + 3000x(-20) = -20,000 kg m/s. Since momentum is conserved the magnitude of the final momentum is 20,000.

(7,4,1,23) Water is traveling in a narrow pipe where the speed $v_1 = 32$ m/s and the pressure is P_1. The pipe widens to a diameter which is twice as big. Which statement is true about the speed v_2 and pressure P_2 in the wide part of the pipe?

A) $v_2 = 8$ m/s; $P_2 > P_1$
B) $v_2 = 8$ m/s; $P_2 = P_1$
C) $v_2 = 8$ m/s; $P_2 < P_1$
D) $v_2 = 16$ m/s; $P_2 > P_1$
E) $v_2 = 16$ m/s; $P_2 < P_1$

Answer: The volume flow is $Q = Av$ is conserved where A is the area. If the diameter increases by a factor of two the velocity must decrease by a factor of four (v_2=8 m/s). As discussed in the lecture and book, $P_2 > P_1$.

(8,5,2,24) A pair of ice skaters are holding hands and spinning around each other with an angular velocity ω. They suddenly pull each other close together. This results in:

A) A decrease in ω because of a decrease in angular momentum.
B) An increase in ω because of a decrease in angular momentum.
C) An increase in ω because of an increase in angular momentum.
D) An increase in ω because angular momentum remains constant.
E) A decrease in ω because angular momentum remains constant.

Answer: Angular momentum is conserved (remains constant), $L = I\omega$. When the radius is reduced I is reduced and thus ω must increase.

(9,6,3,25) A hoop starts from rest and rolls down a ramp which has a height of 2 m and makes an angle of 20° with respect to the horizontal. What is the velocity at the bottom of the ramp?

A) 4.4 m/s
B) 5.1 m/s
C) 6.3 m/s
D) 7.7 m/s
E) 8.9 m/s

Answer: PE at the top equals KE at the bottom: $mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$. For hoop $I = MR^2$ and $\omega = v/R$, so $mgh = mv^2$ which gives v=4.4 m/s.

(10,7,4,1) A block of wood floats on the top of a tank of water. The wood has a density of 750 kg/m^3 and a volume of 0.20 m^3. What is the buoyant force of the water on the block? (The density of water is 1000 kg/m^3.)

A) zero
B) 490 N
C) 980 N
D) 1470 N
E) 1960 N

Answer: Since the block is floating the buoyant force must equal the weight force. $F_g = m\rho V = 1470$ N.

(11,8,5,2) How much work is done by an ideal gas undergoing the cyclic process shown in the figure. P_1= 2 atm, P_2 = 1 atm, V_1 = 0.1 m^3, V_2 = 0.5m^3, where 1 atm = 1.01 x 10^5 N/m^2.

A) 20200 J
B) 40400 J
C) 50500 J
D) 101000 J
E) 181800 J

Answer: The work is the area in the box = (2-1)x(0.5-0.1) atm m^3 =40400 J.

(12,9,6,3) A heat engine absorbs 4000 J of heat and exhausts 3000 J of heat in each cycle. What is the efficiency?

A) 133%
B) 100%
C) 75%
D) 33%
E) 25%

Answer: $e = (Q_{in} - Q_{out})/Q_{in} = 0.25 = 25\%$.

(13,10,7,4) What is the change in entropy when 2 kg of lead melts at 327 ^{o}C? The latent heat of fusion of lead is 2.45 x 10^4 J/kg.

A) 41 J/^{o}K
B) 75 J/^{o}K
C) 82 J/^{o}K
D) 100 J/^{o}K
E) 150 J/^{o}K

Answer: $\Delta S = Q/T$ = 2 x 24500/(327+273) = 82.

(14,11,8,5) A window pane has a glass surface of 1000 cm^2 and a thickness of 3.00 mm. What is the rate of heat transfer by conduction through this glass if the temperature difference across the glass is 30 ^{o}C? The thermal conductivity of glass is 0.84 J/(s m ^{o}K).

A) 84 J/s
B) 840 J/s
C) 2520 J/s
D) 84 x 10^2 J/s
E) 84 x 10^{-2} J/s

Answer: heat flow = $kA\Delta T/L$ = 0.84 x 0.1 x 30 /0.003 = 840.

(15,12,9,6) An immersion heater has a power rating of 1300 watts. It is used to heat water. How long should it take to bring 1.7 liters of water (mass 1.7 kg) from room temperature (20 ^{o}C) to 91 ^{o}C? (c_{water} = 4.18 kJ/kg)

A) 55 s
B) 64 s
C) 120 s
D) 390 s
E) 510 s

Answer: $Pt = mc\Delta T$. t=4180 x 1.7 x 71 /1300 = 390.

(16,13,10,7) An ideal Carnot engine takes in 190 kcal of heat at 60 ^{o}C and exhausts a part of it at 25 ^{o}C. How much work has been done by this engine?

A) 20 kcal
B) 80 kcal
C) 190 kcal
D) 170 kcal
E) 110 kcal

Answer: For a Carnot engine $e = 1 - (T_C/T_H) = 1 - (298/333)$=0.105. $W = eQ_{in} = 20$.

(17,14,11,8) A spherical black body with temperature T is radiating energy at the rate of Q J/s. If the temperature is increased to $2T$ then the power radiated (in units of J/s) is:

A) Q
B) $4Q$
C) $16Q$
D) $Q/4$
E) $Q/16$

Answer: The heat radiated goes at T^4 so is T is increased a factor of two the heat radiated goes up by a factor of 16.

(18,15,12,9) 0.5 kg of ice is heated from -30 ^{o}C to 0 ^{o}C (melting point) and melted. The water (0.5 kg) is then heated to 100 ^{o}C and converted to steam. c_{ice} = 2.1 kJ/kg, c_{water}=4.18 kJ/kg, the heat of fusion is 333.7 kJ/kg, and the heat of vaporization is 2259 kJ/kg. Which of the following is correct?

A) Most heat is used to heat ice from -30 ^{o}C to 0 ^{o}C.
B) Most heat is used in converting ice to water at 0 ^{o}C.
C) Most heat is used in heating water from 0 ^{o}C to 100 ^{o}C.
D) Most heat is used in converting water to steam at 100 ^{o}C.
E) The amount of heat used is the same for all of the above.

Answer: (D).

(19,16,13,10) A string 1 meter long, fixed at both ends, is vibrating in its fundamental frequency of 200 Hz. The wave velocity in the string is:

A) 0.25 m/s
B) 2 m/s
C) 4 m/s
D) 200 m/s
E) 400 m/s

Answer: $v = f\lambda = f2L = 400$.

(20,17,14,11) If the distance from a point source of sound is tripled, then the sound intensity:

A) Decreases by a factor of 9.
B) Decreases by a factor of 3.
C) Stays the same.
D) Decreases by 9 decibels.
E) Decreases by 3 decibels.

Answer: The sound intensity goes as $1/R^2$, so if R changes by three, the intensity decreases a factor of 9.

(21,18,15,12) What is the intensity level in decibels for a sound that has an intensity of 5 x 10^{-5} W/m^2?

A) 57 dB
B) 67 dB
C) 70 dB
D) 77 dB
E) 87 dB

Answer: $I(db) = 10\log(I/I_o)$ where $I_o = 10^{-12}$, $I = 77$ db.

(22,19,16,13) A spring is oscillating with a frequency of 10 Hz. As the spring passes equilibrium which statement is **false**?

A) The kinetic energy is a maximum.
B) The potential energy is zero.
C) The force exerted by the spring is zero.
D) The velocity of the mass is a maximum
E) The acceleration of the mass is a maximum.

Answer: The acceleration is zero at the equilibirum.

(23,20,17,14) You blow lightly across the open end of a half open cylindrical tube of length 0.1 m and excite the tube in its fundamental resonance. If the speed of sound in air is 330 m/s, about what frequency would you hear?

A) 660 Hz
B) 825 Hz
C) 1650 Hz
D) 1320 Hz
E) 3300 Hz

Answer: $f = v/\lambda = v/4L = 825$.

(24,21,18,15) A pendulum is composed of a mass of 6 kg suspended from the ceiling by a 2 m long string. How many complete oscillations will this pendulum make in twenty seconds?

A) 7.0
B) 9.8
C) 12.6
D) 14.4
E) 22.0

Answer: $T = 2\pi\sqrt{(\ell/g)} = 2.8$ s. In 20 seconds there are $20/2.8 = 7.0$ oscillations.

(25,22,19,16) The speed of sound is 330 m/s. Two tuning forks vibrate at 400 Hz. If one of them is at rest and the other is moving away from you at 10 m/s, you will hear beats at a frequency of approximately:

A) 4 Hz
B) 8 Hz
C) 12 Hz
D) 40 Hz
E) 410 Hz

Answer: $f' = f/(1 + (v_{source}/V_{sound}) = 388$. $\Delta f = \mid f - f' \mid$=12.