PHYS 1112 Sample Questions from Previous Final Exam

1. A 3.00 kg box sits in a train moving at a constant velocity along the +*x* direction. The train started to decelerate at a rate of -4.00 m/sec^2. If the static friction coefficient between the box and the train floor is $\mu_s = 0.200$ and the kinetic friction coefficient is $\mu_k = 0.150$, the box would
   A. Remain sitting on the train floor without moving
   B. Move along the +*x* direction relative to the train floor at a uniform speed of 2.53 m/sec
   C. Accelerate relative to the train floor along the +*x* direction at a rate of +7.59 m/sec^2
   D. Move along the $-x$ direction at a uniform speed of 7.59 m/sec
   E. Accelerate relative to the train floor along the +*x* direction at a rate of $+2.53$ m/sec^2

2. During a rainy day, a car is driven at a uniform speed *v* along a circular race course with radius *R*=500 m. The race course is banked at an angle 25.0^o. Suppose at some point the race course is very slippery so that the static friction coefficient between the tire and the road is nearly zero, what is a safe speed *v* for the car not to slip sideways?
   A. *v* should be as small as possible
   B. *v*=47.8 m/sec
   C. *v*=66.6 m/sec
   D. If the friction coefficient is zero, the car is going to slip sideways no matter at what speed
   E. *v* is dependent on the mass of the car, hence there is not enough information to determine the safe speed

3. Earth circulates around the Sun in a nearly circular orbit with a radius $r=1.5\times10^{11}$ m. Since it takes *T*= 365.2 days (=31.55×10^6 sec) to complete one orbit, the mass of the sun, M_s, is given by the expression (with *G* being the gravitational constant)
   A. not enough information for its determination
   B. $M_s = 2\pi r^2 / GT^3$
   C. $M_s = 2\pi r^3 / GT^2$
   D. $M_s = GT^2 / 4\pi^2 r^3$
   E. $M_s = 4\pi^2 r^3 / GT^2$

4. A ball with mass m=0.1 kg is traveling along the positive x direction with v_x=30 m/sec. It is hit by an impulse J=3 N sec along the positive y direction. Its final speed is
   A. 60 m/sec
   B. 90 m/sec
   C. $30\sqrt{2}$ m/sec
   D. $60/\sqrt{2}$ m/sec
   E. $30/\sqrt{2}$ m/sec

5. A box that has a mass of 3.0 kg is dropped from a certain height and hit a spring with a spring constant k=300 N/m. At the point of contact, the box has a speed of 1.0 m/sec, and it is stuck to the spring. What is the resulting amplitude A and period T of oscillation? Assume the mass of the spring to be negligible.
   A. A=1.4 cm and T=10 sec
   B. A=14 cm and T=0.63 sec
   C. A=14 cm and T=10 sec
   D. A=1.4 cm and T=0.63 sec
   E. A=14 cm and T=0.1 sec

6. A satellite orbits the Earth in a circular orbit with radius r and speed v. Suppose the orbiting radius is increased by a factor of 2, in order to stay in a stable orbit the orbiting speed must
   A. $\sqrt{2}v$
   B. $v/\sqrt{2}$
   C. $v/2$
   D. $2v$
   E. Remain the same

7. This question is removed

8. This question is removed

9. A mass is attached to one end of a spring whose other end is fixed. The mass oscillates periodically on a frictionless surface. It is suddenly hit by an impulse along its motion direction. What would be the change in its oscillatory motion?
   A. Both the period and amplitude would change
   B. The period would not change, but the amplitude will change
   C. Not enough information to determine the change
   D. The amplitude would not change, but the period is changed
   E. A., B., and D. are all possible, depending on the magnitude of the impulse

10. Assume that the Earth is orbiting the sun in a perfectly circular orbit. If the Earth is hit by a huge meteorite but its orbiting angular momentum is not changed (this can be the case if the hit is along the radial direction of the orbit), what would be the change in Earth's orbit?
    A. No change
    B. Earth would move in a circular orbit with a larger radius
    C. Earth would move in a circular orbit with a smaller radius
    D. Earth's orbit would not change, but its period is lengthened
    E. Earth's orbit would become elliptical

11. Earth is rotating about its north-south axis with a period of 24 hours. The density of the Earth is not uniform. Generally the density is higher in the core than on the surface. If the mass of the Earth is re-distributed so that the density is the same everywhere, its rotational period should be
    A. longer than 24 hours
    B. shorter than 24 hours
    C. the same
    D. not enough information to determine the outcome
    E. either A. or B., dependent on whether there is energy dissipation during the mass re-distribution

12. A block is sliding down an inclined plane that makes an angle α with the flat surface. The block and the inclined plane has a kinetic friction coefficient $\mu_k = 0.15$. The block is seen to slide down with a constant speed. What is the angle α ?
    A. 8.5°
    B. 81°
    C. Dependent on the mass of the block, hence insufficient information
    D. Not possible to slide down with a constant speed
    E. 10°

13. A block with mass 0.50 kg moving at v_x=1.0 m/sec collides head on with another block with mass 1.0 kg moving at v_x= − 1.0 m/sec. Suppose the collision is inelastic and can therefore dissipate energy, what is the maximum amount of energy that can be dissipated? Hint: what kind of collision (elastic, inelastic, completely inelastic) should it be?
    A. 0.75 J
    B. 0.25 J
    C. 0.67 J
    D. 0.38 J
    E. None of the above

14. Suppose future technology can realize a deep tunnel for bullet trains under the Pacific Ocean, linking China and the United States. If air resistance and rail friction can be minimized, which of the following statements must be false?
    A. The train can utilize Earth's gravity for acceleration and deceleration
    B. The train can use less energy compared to traveling on the surface
    C. The gravitational potential energy of the train is lower on the surface than at the deepest point in the tunnel
    D. Theoretically, the train can execute an oscillatory motion between the two ends of the tunnel
    E. The weight of the train can vary over the course of travel

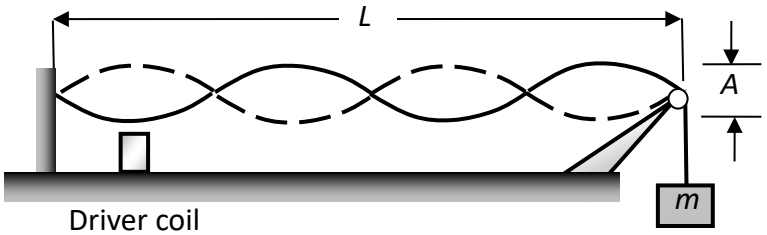
15. Which of the following is a false statement?
A) In a transverse wave the particle motion is perpendicular to the direction of travel of the wave.
B) Not all waves are mechanical in nature.
C) The speed of a wave and the speed of the vibrating particles that constitute the wave are different entities.
D) Waves transport energy and matter from one region to another.
E) A wave in which particles move back and forth in the same direction as the wave is moving is called a longitudinal wave.

16. Two sinusoidal waves of the same period, with amplitudes of 5.0 mm and 7.0 mm, travel in the same direction along a string; they produce a resultant wave with an amplitude of 10.0 mm. The phase constant of the 5.0 mm wave is 0. The phase constant of the 10.0 mm wave is 0.708 rad. What is the phase constant of the 7.0 mm wave?
(A) $\pi/6$
(B) $\pi/3$
(C) 1.2
(D) 1.5
(E) 2.0

17. A student holds a tuning fork vibrating at 440 Hz and walks at 2.00 m/s away from a wall. What beat frequency does he hear between the fork and the echo?
(A) 2 Hz
(B) 3 Hz
(C) 4 Hz
(D) 5 Hz
(E) 6 Hz

18. A whistle of frequency 540 Hz moves in a circle of radius 60.0 cm at an angular speed of 20.0 rad/s. What are the lowest and highest frequencies heard by a listener a long distance away, at rest with respect to the center of the circle?
(A) 520 Hz and 560 Hz
(B) 522 Hz and 560 Hz
(C) 520 Hz and 562 Hz
(D) 522 Hz and 562 Hz
(E) 520 Hz and 588 Hz

Q19 & 20
A metal wire, of length *L* = 0.90 m and linear density μ = 2.00 gram per meter, is fixed at one end and is stretched at the other end by hanging weights of total mass *m* = 0.40 kg. The oscillation has four loops with *A* = 4 mm as shown in the figure. Let the horizontal axis be the *x* axis, and choose the left end of the wire to be located at *x* = 0. Also choose the time *t* = 0 to be the instant shown as the solid curve in the figure, when the displacement of the wire is maximum.



19. The displacement at position x and time t is: (values without specific units are all in SI units.)
(A) $y(x,t) = (2\text{ mm})\,sin(0.45x)\,cos(620t)$
(B) $y(x,t) = (-2\text{ mm})\,sin(14x)\,cos(98t)$
(C) $y(x,t) = (-2\text{ mm})\,sin(14x - 620t)$
(D) $y(x,t) = (2\text{ mm})\,sin(0.45x - 98t)$
(E) $y(x,t) = (-2\text{ mm})\,sin(14x)\,cos(620t)$

20. Which mass *m* can produce three loops oscillating at the same frequency?
(A) 2 kg
(B) 0.3 kg
(C) 0.4 kg
(D) 0.5 kg
(E) 0.7 kg

21. This question is deleted because the topic is not covered in this term.

22. This question is deleted because the topic is not covered in this term.

23. Ethyl alcohol has a boiling point of 78.0°C, a freezing point of -114°C, a heat of vaporization of 879 kJ/kg, a heat of fusion of 109 kJ/kg, and a specific heat of 2.43 kJ/kg·K. How much energy must be removed from 0.510 kg of ethyl alcohol that is initially a gas at 78.0°C so that it becomes a solid at -114°C.

(A)1.23KJ
(B) 238kJ
(C) 742 kJ
(d) 989 kJ
(e) 1455kJ

24. Ice has formed on a shallow pond, and a steady state has been reached, with the air above the ice at -5.0°C and the bottom of the pond at 4.0°C. If the total depth of ice + water is 1.4m, how thick is the ice? (Assume that the thermal conductivities of ice and water are 0.40 and 0.12 cal/m·°C·s, respectively. 1 cal = 4.184 J. Ignore the water convection.)

(A) 0.2m
(B) 0.38m
(C) 0.70m
(D) 1.0m
(E) 1.1m

25. When a gas in a cylinder is compressed at constant temperature by a piston, the pressure of the gas increases. Consider the following three statements.

I. The rate at which the molecules collide with the piston increases.
II. The root-mean-square speed of the molecules increases.
III. The molecules collide with each other more often.

Which statement(s) correctly explain the increase in pressure?

(a) I only
(b) II only
(c) I and II only
(d) I and III only
(e) I, II and III

26. At what temperature does the root-mean-square speed of H_2 equal the escape speed from the Moon? The mass of H_2 molecule is 3.32×10^{-27}kg.
(A) -30.0°C
(B) 28.0°C
(C) 179°C
(D) 450°C
(E) 1030°C

27. A container holds a mixture of 1.00 mol of monoatomic gas and 2.00 mol of diatomic gas at room temperature. What is the molar specific heat of the mixture?
(A) 12.5 J/mol·K
(B) 18.0 J/mol·K
(D) 20.8 J/mol·K
(D) 23.5 J/mol·K
(E) 29.1 J/mol·K

28. A container is filled with a mixture of helium and oxygen gases. A thermometer in the container indicates that the temperature is 22°C. Which gas molecules have the greater root-mean-square speed?

A) The oxygen molecules do because they are diatomic.
B) The helium molecules do because they are monatomic.
C) It is the same for both because the temperatures are the same.
D) The helium molecules do because they are less massive.
E) The oxygen molecules do because they are more massive.

29. A Carnot cycle engine operates between a low temperature reservoir at 20.0°C and a high temperature reservoir at 800°C. If the engine is required to output 20.0 kJ of work per cycle, how much heat must the high temperature reservoir transfer to the engine during each cycle?

A) 20.5 kJ
B) 27.5 kJ
C) 800 kJ
D) 73.2 kJ
E) 39.2 kJ

30. A quantity of ideal gas requires 800 kJ to raise the temperature of the gas by 10.0 K when the gas is maintained at constant volume. The same quantity of gas requires 900 kJ to raise the temperature of the gas by 10.0 K when the gas is maintained at constant pressure. What is the heat capacity ratio γ of this gas?
A) 1.40
B) 1.13
C) 0.889
D) 1.67
E) 1.22

31. A container of ideal gas has a movable frictionless piston. This container is placed in a very large water bath and slowly compressed so that the temperature of the gas remains constant and equal to the temperature of the water. Which of the following statement about this gas is true for this process?

A) The average speed of the gas molecules decreases during the compression.
B) Heat leaves the gas during the compression.
C) Since the temperature of the gas remains constant, the pressure of the gas must also remain constant.
D) Since the gas and water are at the same temperature, no heat can flow between them, which makes this an adiabatic compression.
E) The internal energy of the gas increases during the compression because work is done on the gas.

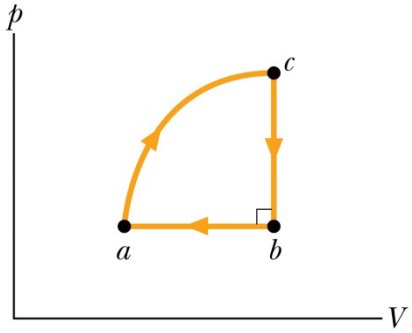
32. When an ideal gas increases in volume at constant pressure, the average kinetic energy of the gas molecules
A) increases.
B) decreases.
C) does not change.
D) may either increase or decrease, depending on whether or not the process is carried out adiabatically.
E) may or may not change, but insufficient information is given to make such a determination.

33. Is it possible to transfer heat from a cold reservoir to a hot reservoir?
A) No; this is forbidden by the second law of thermodynamics.
B) Yes; this will happen spontaneously.
C) Yes, but work will have to be done on the system.
D) Theoretically yes, but it hasn't been accomplished yet.
E) No; this is forbidden by the first law of thermodynamics.

34. An engine manufacturer makes the claim that the engine they have developed will, on each cycle, take 100 J of heat out of boiling water at 100°C, do mechanical work of 80 J, and exhaust 20 J of heat at 10°C. What, if anything, is wrong with this claim?

A) The heat exhausted must always be greater than the work done according to the second law of thermodynamics.
B) There is nothing wrong with this claim because 100 J = 20 J + 80 J.
C) This engine violates the second law of thermodynamics.
D) An engine would operate by taking in heat at the lower temperature and exhausting heat at the higher temperature.
E) This engine violates the first law of thermodynamics because 100 J + 20 J ≠ 80 J.

35. The p-V diagram displays a closed cycle for an ideal gas. From c to b, 40J is transferred from the gas as heat. From b to a, 130J is transferred from the gas as heat and the magnitude of the work done on the gas is 80J. From a to c, 400J is transferred to the gas as heat. What is the work done by the gas from a to c?



A) 440J
B) 310J
C) 150J
D) 490J
E) 650J

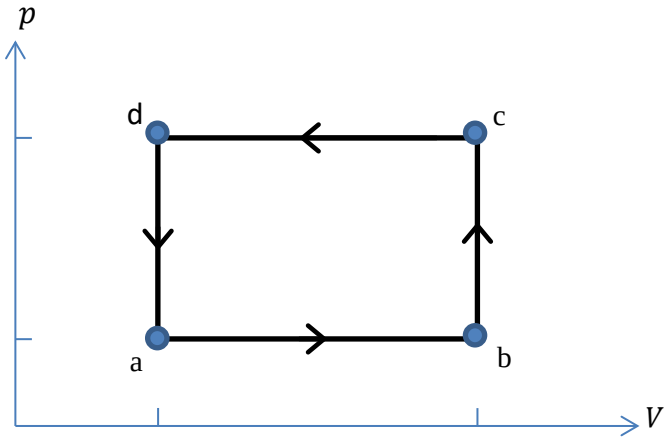
Q36 & Q37 concern the following situation:
A sample of ideal gas expands from an initial pressure, volume and temperature of 10 Pa, 1.0 m^3 and 100K to a final volume of 2.0 m^3. During the expansion, the pressure and volume are related by the equation $p = aV^2$, where $a = 10$ N/m^8.

36. Determine the work done by the gas during the expansion.
A) 10 J
B) 30 J
C) 57 J
D) 33 J
E) 23 J

37. Determine the final temperature when the volume is 2.0 m^3.
A) 50 K
B) 200 K
C) 400 K
D) 800 K
E) 1000 K

38. In a bottle of champagne, the pocket of gas (primary CO_2) between the liquid and the cork is at pressure of $p_i = 5.00$ atm. When the bottle is opened, the gas undergoes an adiabatic expansion until its pressure matches the air pressure at 1.00 atm. Assume that the ratio of the molar specific heats is $\gamma = \frac{4}{3}$. If the gas has initial temperature T_i =5.00 ^oC, what is its temperature at the end of the expansion?
A) 186 ^oC
B) 4 ^oC
C) -87 ^oC
D) 0 ^oC
E) -14 ^oC

Q39 & Q40 concern the following situation:



Consider a refrigerator which uses 2.00 moles of ideal monoatomic gas as the working substance. In operation, the gas undergoes a rectangular cycle shown in the p-V diagram above. The temperatures at state a, b, c and d are 100K, 150K, 450K and 300K, respectively.

39. Find the coefficient of performance, $K = \frac{\text{total heat absorbed by the system}}{\text{net workdone on the system}}$, of the refrigerator.

A) 5.75
B) 0.763
C) 1.81
D) 0.552
E) 6.64

40. Find the work done by the gas from a to b.

A) 3300 J
B) 2100 J
C) 830 J
D) 1300 J
E) 0 J

41. A circular plate with radius 0.500 m and mass 5.00 kg is hung on the wall, fixed at a point that is 0.300 m above its center. The plate can freely rotate about the fixed point with no friction. A very short-duration impulse of 5.00 N sec, along a direction that is tangential to the circumference of the circular plate, is applied at the bottom point of the plate. From energy conservation, what is the maximum angle of rotation (away from the equilibrium position) attained by the plate?

A. 87.0^o
B. 29.6^o
C. 60.4^o
D. 56.0^o
E. None of the above

42 & 43

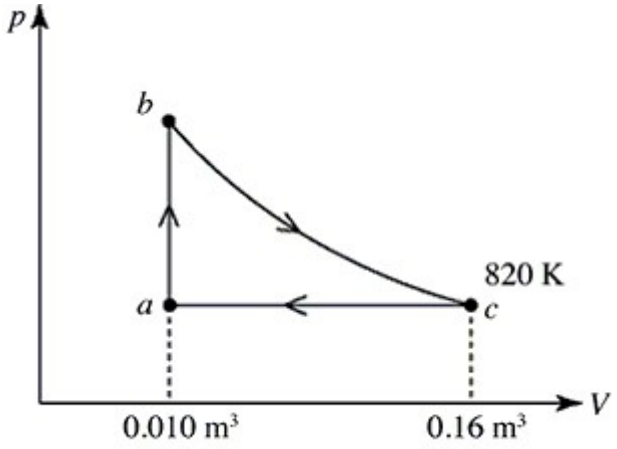
Container A holds an ideal gas at a pressure of 5.0×10^5Pa and a temperature of 300K. It is connected by a thin tube (and a closed vale) to container B, with four times the volume of A. Container B holds the same ideal gas at a pressure of 1.0×10^5Pa and a temperature of 400K.

42. What is the equilibrium pressure of the system after the valve is opened? (Hint: The number of molecules and the total energy of the system are conserved.)

(A) depending on the type of the gas (monoatomic or diatomic)
(B) 1.5×10^5Pa
(C) 1.8×10^5Pa
(D) 2.0×10^5Pa
(E) 2.3×10^5Pa

43. If the valve is opened to allow the pressures to equalize, but the temperature of each container is maintained. What then is the pressure?
(A) 1.0×10^5 Pa
(B) 1.12×10^5 Pa
(C) 1.7×10^5 Pa
(D) 2.0×10^5 Pa
(E) 2.7×10^5 Pa

44. A heat engine takes 2.0 moles of an ideal gas through the reversible cycle *abca*, on the *pV* diagram shown in the figure. The path *bc* is an isothermal process. The temperature at *c* is 820 K, and the volumes at *a* and *c* are 0.010 m^3 and 0.16 m^3, respectively. The molar heat capacity at constant volume, of the gas, is 37 J/mol·K. The thermal efficiency of the engine, $e = \frac{\text{net workdone by the system}}{\text{total heat input to the system}}$, is closest to



A) 0.26
B) 0.33
C) 0.53
D) 0.026
E) 0.40

45. An ideal gas undergoes a process in which the heat absorbed by the gas always equals to a half of workdone by the gas. What is the relation between the temperature and the volume of the gas in the process?

A) $TV^{(\gamma-2)}$ = constant

B) $TV^{2(\gamma-1)}$ = constant

C) $TV^{(\gamma-1)/2}$ = constant

D) $TV^{(\gamma-1)}$ = constant

E) $TV^{(2\gamma-1)}$ = constant

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Answers:

1. E
2. B
3. E
4. C
5. B
6. B
7.
8.
9. B
10. E
11. A
12. A
13. C
14. C
15. D
16. C
17. D
18. B
19. E
20. E
21.
22.
23. C
24. E
25. A
26. C
27. B
28. D
29. B
30. B
31. B
32. A
33. C
34. C
35. B
36. E
37. D
38. C
39. A
40. C

41 C
42 C
43 D
44 A
45 C