

Name: S. I. D.:

Physics 220

Final Exam (Version A)

Summer 06

THIS EXAM CONTAINS 36 QUESTIONS.

ANSWERS ARE ROUNDED. PICK THE BEST ANSWER TO EACH QUESTION.

- Each of the following questions (1 - 15) is worth 6 points

1. A vertical block-spring system on earth has a period of 6.0 s. What is the period of this same system on the moon where the acceleration due to gravity is roughly 1/6 that of earth?
A) 1.0 s
B) 2.4 s
C) 6.0 s
D) 15 s
E) 36 s

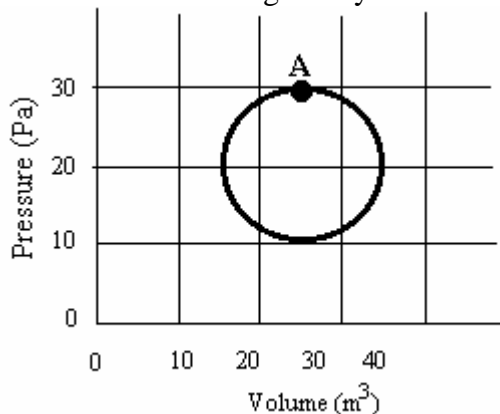
2. Which one of the following statements is true concerning an object executing simple harmonic motion?
A) Its velocity is never zero.
B) Its acceleration is never zero.
C) Its velocity and acceleration are simultaneously zero.
D) Its velocity is zero when its acceleration is a maximum.
E) Its maximum acceleration is equal to its maximum velocity.

3. The velocity of a certain simple harmonic oscillator is given by $v = -(12 \text{ m/s}) \sin [(6.0 \text{ rad/s}) t]$. What is the amplitude of the simple harmonic motion?
A) 2.0 m
B) 4.0 m
C) 6.0 m
D) 8.0 m
E) 12 m

4. Complete the following statement: Young's modulus cannot be applied to
- A) a stretched wire.
 - B) a compressed rod.
 - C) a bending beam.
 - D) a compressed liquid.
 - E) a stretched rubber band.
5. In a car lift, compressed air with a gauge pressure of 4.0×10^5 Pa is used to raise a piston with a circular cross-sectional area. If the radius of the piston is 0.17 m, what is the maximum mass that can be raised using this piston?
- A) 530 kg
 - B) 3700 kg
 - C) 9800 kg
 - D) 22 000 kg
 - E) 41 000 kg
6. Which one of the following statements concerning the buoyant force on an object submerged in a liquid is true?
- A) The buoyant force depends on the mass of the object.
 - B) The buoyant force depends on the weight of the object.
 - C) The buoyant force is independent of the density of the liquid.
 - D) The buoyant force depends on the volume of the liquid displaced.
 - E) The buoyant force will increase with depth if the liquid is incompressible.
7. Three thermometers are in the same water bath. After thermal equilibrium is established, it is found that the Celsius thermometer reads 100°C , the Fahrenheit thermometer reads 212°F , and the Kelvin thermometer reads 273 K. Which one of the following statements is the most reasonable conclusion?
- A) The Kelvin thermometer is incorrect.
 - B) The Celsius thermometer is incorrect.
 - C) The Fahrenheit thermometer is incorrect.
 - D) All three thermometers are incorrect.
 - E) The three thermometers are at different temperatures.

8. Which one of the following statements best explains why convection does not occur in solids?
- A) Molecules in a solid are more closely spaced than in a gas.
 - B) The molecules in a solid are not free to move throughout its volume.
 - C) Molecules in a solid vibrate at a lower frequency than those of a liquid.
 - D) Solids are more compressible than liquids.
 - E) Solids are less compressible than gases.
9. A granite wall has a thickness of 0.61 m and a thermal conductivity of $2.1 \text{ W}/(\text{m} \cdot \text{C}^\circ)$. The temperature on one face of the wall is $3.2 \text{ }^\circ\text{C}$ and $20.0 \text{ }^\circ\text{C}$ on the opposite face. How much heat is transferred in one hour through each square meter of the granite wall?
- A) $210\,000 \text{ J}/\text{m}^2$
 - B) $106\,000 \text{ J}/\text{m}^2$
 - C) $77\,000 \text{ J}/\text{m}^2$
 - D) $1800 \text{ J}/\text{m}^2$
 - E) $58 \text{ J}/\text{m}^2$
10. The power radiated by a distant star is $4.2 \times 10^{27} \text{ W}$. The radius of the star, which may be considered a perfect radiator, is $1.06 \times 10^{10} \text{ m}$. Determine the surface temperature of the star.
- A) 2690 K
 - B) 4430 K
 - C) 7240 K
 - D) 8510 K
 - E) 9770 K
11. Argon gas at 305 K is confined within a constant volume at a pressure P_1 . If the gas has a pressure P_2 when it is cooled to 195 K, what is the ratio of P_2 to P_1 ?
- A) 0.410
 - B) 0.639
 - C) 0.717
 - D) 1.28
 - E) 1.56

12. Complete the following statement: Walls that separate a system from its surroundings and permit heat to flow through them are called
- diathermal walls.
 - adiabatic walls.
 - entropic walls.
 - isobaric walls.
 - isochoric walls.
13. An ideal gas absorbs 750 J of heat as it performs 625 J of work. What is the resulting change in temperature if there is 1.3 moles of the gas?
- 8.6 K
 - 4.3 K
 - 7.7 K
 - 9.6 K
 - 23 K
14. Calculate the speed of the oxygen molecules in the air if the temperature is 5.00 °C.
Note: The mass of the oxygen molecule is 31.9988 u.
- 62.0 m/s
 - 86.3 m/s
 - 328 m/s
 - 465 m/s
 - 487 m/s
15. In a reversible heat engine, one mole of an ideal gas is carried through a circular cycle beginning and ending at point A as shown in the figure. Which one of the following statements concerning this system is false?

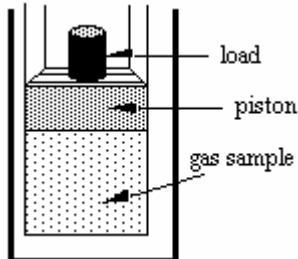


- The entropy must increase in one cycle.
- The heat added in one cycle must be 314 J.
- The work done in completing one cycle is 314 J.
- The change in internal energy for one cycle is zero.
- The internal energy for this system is dependent on its state.

- Each of the following questions (16 - 36) is worth 10 points

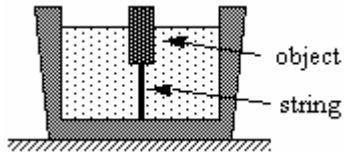
16. A 1.0-kg object is suspended from a spring with $k = 16 \text{ N/m}$. The mass is pulled 0.25 m downward from its equilibrium position and allowed to oscillate. What is the maximum kinetic energy of the object?
- A) 0.25 J
 - B) 0.50 J
 - C) 1.0 J
 - D) 2.0 J
 - E) 4.0 J
17. An iron ball hangs from a 24-m steel cable and is used in the demolition of a building at a location where the acceleration due to gravity is 9.9 m/s^2 . The ball is swung outward from its equilibrium position for a distance of 4.5 m. Assuming the system behaves as a simple pendulum, find the maximum speed of the ball during its swing.
- A) 1.9 m/s
 - B) 7.0 m/s
 - C) 11 m/s
 - D) 2.9 m/s
 - E) 9.8 m/s
18. The average density of the material in intergalactic space is approximately $2.5 \times 10^{-27} \text{ kg/m}^3$. What is the volume of a gold sample, $\rho = 19\,300 \text{ kg/m}^3$, that has the same mass as $8.0 \times 10^{24} \text{ m}^3$ of intergalactic space?
- A) $1.0 \times 10^{-6} \text{ m}^3$
 - B) $2.0 \times 10^{-5} \text{ m}^3$
 - C) $5.0 \times 10^{-5} \text{ m}^3$
 - D) $8.0 \times 10^{-5} \text{ m}^3$
 - E) $1.0 \times 10^{-4} \text{ m}^3$

19. A gas sample is confined to a chamber with a movable piston. A small load is placed on the piston and the system is allowed to reach equilibrium. If the weight of the piston and the load is 70.0 N and the piston has an area of $5.0 \times 10^{-4} \text{ m}^2$, what is the pressure exerted on the piston by the gas? **Note:** Atmospheric pressure is $1.013 \times 10^5 \text{ Pa}$.

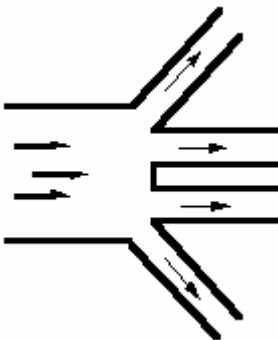


- A) $2.8 \times 10^4 \text{ Pa}$
B) $5.6 \times 10^4 \text{ Pa}$
C) $7.3 \times 10^4 \text{ Pa}$
D) $1.4 \times 10^5 \text{ Pa}$
E) $2.4 \times 10^5 \text{ Pa}$
20. At a location where the acceleration due to gravity is 9.807 m/s^2 , the atmospheric pressure is $9.891 \times 10^4 \text{ Pa}$. A barometer at the same location is filled with an unknown liquid. What is the density of the unknown liquid if its height in the barometer is 1.163 m?
- A) 210 kg/m^3
B) 4336 kg/m^3
C) 5317 kg/m^3
D) 8672 kg/m^3
E) 9688 kg/m^3
21. A child wants to pump up a bicycle tire so that its pressure is $2.5 \times 10^5 \text{ Pa}$ above that of atmospheric pressure. If the child uses a pump with a circular piston 0.035 m in diameter, what force must the child exert?
- A) 120 N
B) 240 N
C) 340 N
D) 930 N
E) 1300 N

22. A 2-kg block displaces 10 kg of water when it is held fully immersed. The object is then tied down as shown in the figure; and it displaces 5 kg of water. What is the tension in the string?



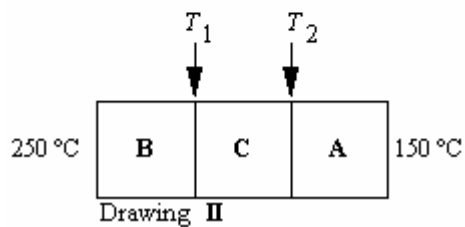
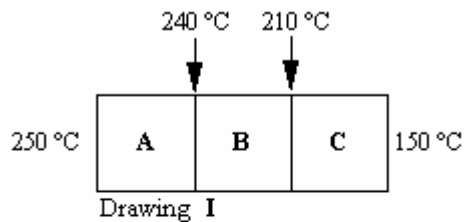
- A) 10 N
 B) 20 N
 C) 30 N
 D) 70 N
 E) 100 N
23. Which one of the following statements concerning *streamline flow* is true?
 A) At any given point in the fluid, the velocity is constant in time.
 B) Streamline flow occurs when there are sharp obstacles in the path of a fast-moving fluid.
 C) Streamline flow is described by Pascal's principle.
 D) Streamline flow is described by Archimedes' principle.
 E) The velocity vectors are the same for all particles in the fluid.
24. Water is flowing through a channel that is 12 m wide with a speed of 0.75 m/s. The water then flows into four identical channels which have a width of 4.0 m. The depth of the water does not change as it flows into the four channels. What is the speed of the water in one of the smaller channels?



- A) 0.56 m/s
 B) 2.3 m/s
 C) 0.25 m/s
 D) 0.75 m/s
 E) 0.12 m/s

25. The coefficient of linear expansion of aluminum is $23 \times 10^{-6}/\text{C}^\circ$. A circular hole in an aluminum plate is 2.725 cm in diameter at 0°C . What is the diameter of the hole if the temperature of the plate is raised to 100°C ?
- A) 0.0063 cm
 - B) 2.728 cm
 - C) 2.731 cm
 - D) 2.757 cm
 - E) 2.788 cm
26. At a certain temperature, a simple pendulum has a period of 1.500 seconds. The support wire is made of silver and has a coefficient of linear thermal expansion of $1.90 \times 10^{-5}/\text{C}^\circ$. How much must the temperature be increased to increase the period to 1.506 seconds?
- A) 118°C
 - B) 221°C
 - C) 316°C
 - D) 434°C
 - E) 528°C
27. Two spheres, labeled A and B have identical masses, but are made different substances. The specific heat capacity of sphere A is $440 \text{ J/kg} \cdot \text{C}^\circ$ and that of sphere B is $160 \text{ J/kg} \cdot \text{C}^\circ$. The spheres are initially at 21°C ; and the same quantity of heat is added to each sphere. If the final temperature of sphere A is 72°C , what is the final temperature of sphere B?
- A) 160°C
 - B) 140°C
 - C) 111°C
 - D) 51°C
 - E) 39°C
28. Determine the latent heat of vaporization of unknown substance X in kcal/g if 3.0 g of boiling liquid X are completely vaporized in 1.5 hours by an energy source of 10 kcal/h.
- A) 5 kcal/g
 - B) 15 kcal/g
 - C) 27 kcal/g
 - D) 30 kcal/g
 - E) 57.9 kcal/g

29. A slab of insulation is made of three layers, as Drawing I indicates. Each of the layers A, B, and C has the same thickness, but a different thermal conductivity. Heat flows through the slab, and the temperatures are as shown. What are the temperatures T_1 and T_2 in Drawing II where the layers are arranged in a different order?

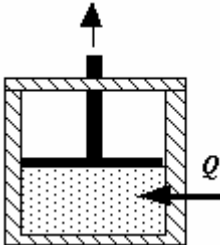


- A) $T_1 = 230\text{ °C}$ and $T_2 = 170\text{ °C}$
- B) $T_1 = 200\text{ °C}$ and $T_2 = 180\text{ °C}$
- C) $T_1 = 220\text{ °C}$ and $T_2 = 160\text{ °C}$
- D) $T_1 = 180\text{ °C}$ and $T_2 = 160\text{ °C}$
- E) $T_1 = 210\text{ °C}$ and $T_2 = 190\text{ °C}$

30. An ideal gas with a fixed number of molecules is maintained at a constant pressure. At 30.0 °C , the volume of the gas is 1.50 m^3 . What is the volume of the gas when the temperature is increased to 75.0 °C ?

- A) 0.60 m^3
- B) 1.30 m^3
- C) 1.72 m^3
- D) 2.45 m^3
- E) 3.75 m^3

31. Enclosed beneath the moveable piston in the figure is 4.8 moles of a monatomic ideal gas. The gas performs work on the piston as 2300 J of heat are added from the surroundings. During the process, the temperature of the gas decreases by 45 K. How much work does the gas perform?



- A) 5000 J
B) 3200 J
C) 1400 J
D) 600 J
E) 400 J
32. What change in temperature occurs when 1200 J of heat are removed from 4.0 moles of monatomic gas under constant pressure?
- A) -8.3 K
B) -11 K
C) -14 K
D) -28 K
E) -36 K
33. A gasoline engine with an efficiency of 0.40 generates 1500 W of power. If a liter of gasoline has an energy content of 3.7×10^7 J, how many liters of gasoline does the engine consume each hour?
- A) 0.36
B) 0.48
C) 1.4
D) 2.8
E) 6.9

34. A wave has an amplitude of 0.35 m, a frequency of 1.05×10^6 Hz, and travels in the positive x direction at the speed of light, 3.00×10^8 m/s. Which one of the following equations correctly represents this wave?
- A) $y = 0.35 \sin (6.60 \times 10^6 t - 0.022x)$
 - B) $y = 0.35 \sin (6.60 \times 10^6 t + 0.022x)$
 - C) $y = 0.35 \sin (286t - 1.05 \times 10^6 x)$
 - D) $y = 0.35 \sin (286t + 1.05 \times 10^6 x)$
 - E) $y = 0.35 \sin (1.05 \times 10^6 t + 3.00 \times 10^8 x)$
35. A source moving through water at 10 m/s generates water waves with a frequency of 5.0 Hz. The speed of these water waves relative to the water surface is 20.0 m/s. The source approaches an observer who is at rest in the water. What wavelength would be measured for these waves by the stationary observer?
- A) 1.0 m
 - B) 2.0 m
 - C) 4.0 m
 - D) 6.0 m
 - E) 8.0 m
36. A certain string on a piano is tuned to produce middle C ($f = 261.63$ Hz) by carefully adjusting the tension in the string. For a fixed wavelength, what is the frequency when this tension is doubled?
- A) 130.08 Hz
 - B) 185.00 Hz
 - C) 370.00 Hz
 - D) 446.63 Hz
 - E) 523.26 Hz

Some Equations You Might Find Useful:

$$d = A \sin(\omega t - kx) \quad \omega_{spr} = \sqrt{k/m} \quad \omega = 2\pi f$$

$$F = -kx \quad \omega_{pen} = \sqrt{g/L} \quad T = \frac{2\pi}{\omega}$$

$$A_1 v_1 = A_2 v_2 \quad \rho = \frac{m}{V}$$

$$P_1 + \frac{1}{2} \rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2} \rho v_2^2 + \rho g h_2 \quad P = \frac{F}{A}$$

$$Tk_\beta = \frac{2}{3} KE \quad F_B = W_{fluid}$$

$$v = f\lambda \quad I = \frac{P}{4\pi r^2} \quad \frac{F}{A} = Y \frac{\Delta L}{L_0}$$

$$\beta = 10 \log(I/I_0) \quad v = \sqrt{\frac{\gamma kT}{m}} \quad v = \sqrt{\frac{F}{\mu}}$$

$$I_0 = 10^{-12} \text{ W/m}^2 \quad v = \sqrt{\frac{B}{\rho}} \quad v = \sqrt{\frac{Y}{\rho}}$$

$$R = 8.31 \text{ J/mol} \cdot \text{K}$$

$$\frac{\Delta L}{L_0} = \alpha \Delta T \quad T_F = \frac{9}{5} T_C + 32$$

$$\frac{\Delta V}{V_0} = \beta \Delta T \quad PV = nRT \quad f_{obs} = f_{source} \left(\frac{1 \pm \frac{v_{obs}}{v_{sound}}}{1 \pm \frac{v_{source}}{v_{sound}}} \right)$$

$$U = \frac{3}{2} N k_B T$$

$$\frac{mv^2}{3} = k_\beta T \quad \Delta U = Q - W \quad Q = cm \Delta T$$

$$KE_{trans} = \frac{3}{2} k_\beta T \quad W = nRT \ln \left(\frac{V_f}{V_i} \right) \quad Q = mL$$

$$W = P \Delta V$$

$$e = 1 - \frac{Q_C}{Q_H}$$

$$e = 1 - \frac{T_C}{T_H}$$

$$e_R = \frac{T_C / T_H}{1 - T_C / T_H}$$

$$e_{pump} = \frac{1}{1 - T_C / T_H}$$

$$PE = \frac{1}{2} kx^2$$

$$k_B = 1.38 \times 10^{-23} \text{ J/K}$$

$$N_A = 6.02 \times 10^{23}$$

$$1 \text{ atm} = 1.013 \times 10^5 \text{ Pa}$$

Answer Key -- final "summer06"

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