
Answer Key: Honors Physics 2nd Semester

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Honors Physics - Second Semester - Final Exam

Multiple Choice Questions [64 pts; 2 pts each]

1. Which of the following summarizes Archimedes' principle?

(A) When the velocity of a fluid is high, the pressure is low.

Incorrect. The buoyant force on an object immersed in a fluid is equal to the weight of the fluid it displaces.

(B) A fluid exerts a pressure in all directions.

Incorrect. The buoyant force on an object immersed in a fluid is equal to the weight of the fluid it displaces.

(C) The buoyant force on an object immersed in a fluid is equal to the weight of the fluid it displaces.

Correct. This is Archimedes' principle.

2. Which of the following is true about a sound wave?

(A) It is a transverse wave.

Incorrect. It is a longitudinal wave.

(B) It is a longitudinal wave.

Correct. A sound wave is a longitudinal wave.

(C) It is an s-wave.

Incorrect. It is a longitudinal wave.

3. Pipe A with a 10 cm diameter is connected to pipe B with a 5 cm diameter by a short tapered connection. A fluid flows steadily through the connected pipes and the density of the fluid is constant throughout both pipes. How does the the pressure at a center point in pipe A compare to that at a center point in pipe B?

(A) $p_A > p_B$

Incorrect. The pressure is higher in pipe B relative to pipe A.

(B) $p_A = p_B$

Incorrect. The pressure is higher in pipe B relative to pipe A.

(C) $p_A > p_B$

Correct. The pressure is higher in larger diameter pipe.

4. If an object is situated at the focal length F of a converging lens, what the distance from the lens to the image formed by the lens?

- (A) F
Incorrect. The image is at infinity.
- (B) $2F$
Incorrect. The image is at infinity.
- (C) Infinity
Correct. The image is at infinity.

5. What happens to the average kinetic energy of a gas molecule if its temperature is doubled?

- (A) Its new kinetic energy is half as much.
Incorrect. Its new kinetic energy is twice as much.
- (B) Its new kinetic energy is twice as much.
Correct. This follows from kinetic theory.
- (C) Its new kinetic energy is four times as much.
Incorrect. Its new kinetic energy is twice as much.

6. What is the process of building a larger nucleus from smaller nuclei known as?

- (A) Nuclear fusion
Correct. Hydrogen fusion produces helium.
- (B) Nuclear fission
Incorrect. It is fusion.
- (C) Nuclear force
Incorrect. It is fusion.

7. What is the number of molecules in one mole of a substance known as?

- (A) Boltzmann's number
Incorrect. It is Avogadro's number.
- (B) Avogadro's number
Correct. It is Avogadro's number.
- (C) Archimedes number
Incorrect. It is Avogadro's number.

8. What is the transfer of energy by the mass movement of molecules from one place to another known as?

(A) Conduction

Incorrect. It is known as convection.

(B) Convection

Correct. It is known as convection.

(C) Radiation

Incorrect. It is known as convection.

9. Which of the following has a relatively low thermal conductivity?

(A) Steel

Incorrect. Fiberglass has a relatively low thermal conductivity.

(B) Copper

Incorrect. Fiberglass has a relatively low thermal conductivity.

(C) Fiberglass

Correct. Fiberglass has a relatively low thermal conductivity.

10. The energy of a hydrogen electron in the ground state is -13.6 eV. What is the ionization energy of hydrogen?

(A) 6.8 eV

Incorrect. It is 13.6 eV.

(B) -27.2 eV

Incorrect. It is 13.6 eV.

(C) 13.6 eV

Correct. It is 13.6 eV.

11. What is the heat required for a material to undergo a phase change called?

(A) Specific heat

Incorrect. It is latent heat.

(B) Ordinary heat

Incorrect. It is latent heat.

(C) Latent heat

Correct. It is latent heat.

12. A clock is moving near the speed of light relative to an observer holding another clock. Which of the following is true?

- (A) The moving clock appears to run faster to the observer than his own clock.
Incorrect. The moving clock appears to run slower to the observer than his own clock.
- (B) The moving clock appears to run the same to the observer as his own clock.
Incorrect. The moving clock appears to run slower to the observer than his own clock.
- (C) The moving clock appears to run slower to the observer than his own clock.
Correct. The moving clock appears to run slower to the observer than his own clock.

13. What condition is required for a process to be adiabatic?

- (A) The system's temperature remains constant.
Incorrect. The system has no net heat flow with its surroundings.
- (B) The system's pressure remains constant.
Incorrect. The system has no net heat flow with its surroundings.
- (C) The system has no net heat flow with its surroundings.
Correct. The system has no net heat flow with its surroundings.

14. What is the physical meaning of the “work function” of a photosensitive material?

- (A) The minimum energy needed to dislodge an electron.
Correct. It is the minimum energy needed to dislodge an electron.
- (B) The maximum kinetic energy of a dislodged electron.
Incorrect. It is the minimum energy needed to dislodge an electron.
- (C) The energy needed to stop the most energetic electrons in a photocell.
Incorrect. It is the minimum energy needed to dislodge an electron.

15. Which of the following is identical to the nucleus of a helium atom?

- (A) A beta particle
Incorrect. It is an alpha particle.
- (B) An alpha particle
Correct. It has two protons and two neutrons.
- (C) A tritium particle
Incorrect. It is an alpha particle.

16. Two copper rods, initially at the same temperature, were both heated to some higher identical temperature. Rod A increased in length 0.1 cm and rod B increased in length 0.2 cm. If the initial length of Rod A was 50 cm long, what was the initial length of rod B?

(A) 100 cm

Correct. Rod B was initially twice as long.

(B) 75 cm

Incorrect. The answer is 100 cm.

(C) 50.1 cm

Incorrect. The answer is 100 cm.

17. What type of nuclear reaction is involved in the decay of cobalt-60 (atomic no. = 27) to nickel-60 (atomic no. = 28)?

(A) beta decay

Correct. It is beta decay.

(B) alpha decay

Incorrect. It is beta decay.

(C) fission

Incorrect. It is beta decay.

18. Box A has a mass of 15 kg and a volume of 0.4 m^3 , and box B has a mass of 20 kg and a volume of 0.3 m^3 . Both are lying at the bottom of a swimming pool. How do the buoyant forces on the boxes compare?

(A) The buoyant force on box A is greater than that on box B.

Incorrect. The buoyant force on box A is less than that on box B.

(B) The buoyant force on box A is the same as that on box B.

Incorrect. The buoyant force on box A is less than that on box B.

(C) The buoyant force on box A is less than that on box B.

Correct. The buoyant force on box A is greater than that on box B.

19. What holds together the nucleons in a nucleus?

(A) Binding energy

Incorrect. It is the strong nuclear force.

(B) Strong nuclear force

Correct. It is the strong nuclear force.

(C) Electrostatic force

Incorrect. It is the strong nuclear force.

20. The length of a spaceship at rest on the Earth is L_0 . The spaceship then flies by the Earth at close to the speed of light. What is its length L as observed by someone on Earth?

(A) $L < L_0$

Correct. Its length appears contracted to an observer on Earth.

(B) $L = L_0$

Incorrect. Its length appears contracted to an observer on Earth.

(C) $L > L_0$

Incorrect. Its length appears contracted to an observer on Earth.

21. What is a blackbody?

(A) A perfect insulator.

Incorrect. It is a perfect emitter of radiant energy.

(B) A object that emits no energy.

Incorrect. It is a perfect emitter of radiant energy.

(C) A perfect emitter of radiant energy.

Correct. It is a perfect emitter (and absorber) of radiant energy.

22. What is it called when a massive galaxy bends the path of light from a star?

(A) Gravitational lensing

Correct. It is called gravitational lensing.

(B) Gravitational redshift

Incorrect. It is called gravitational lensing.

(C) Gravitational pulsing

Incorrect. It is called gravitational lensing.

23. Which of the following summarizes the principle of equivalence in the general theory of relativity?

(A) All frames of reference are equivalent.

Incorrect. It is impossible to distinguish between the effects of a gravitational field and the effects of an equivalent acceleration.

(B) It is impossible to distinguish between the effects of a gravitational field and the effects of an equivalent acceleration.

Correct. This is the basic statement of the principle of equivalence.

(C) Gravitational fields are equivalent in all frames of reference.

Incorrect. It is impossible to distinguish between the effects of a gravitational field and the effects of an equivalent acceleration.

24. Which of the following supports the Big Bang theory for the formation of the universe?

(A) The expansion of the universe.

Incorrect. The Big Bang is supported by both the expansion of the universe and the cosmic microwave background.

(B) The cosmic microwave background.

Incorrect. The Big Bang is supported by both the expansion of the universe and the cosmic microwave background.

(C) Both of the above.

Correct. The Big Bang is supported by both the expansion of the universe and the cosmic microwave background.

25. The velocity and distance of a galaxy to an Earth observer is related by what?

(A) Boltzmann's constant

Incorrect. It's Hubble's constant.

(B) Planck's constant

Incorrect. It's Hubble's constant.

(C) Hubble's constant

Correct. It's Hubble's constant.

26. The current at a certain point in a circuit is 5.0 A. How much charge passes that point in 10 s?

(A) 0.5 C

Incorrect. The amount of charge is 50 C.

(B) 2.0 C

Incorrect. The amount of charge is 50 C.

(C) 50 C

Correct. The amount of charge passing that point is 50 C.

27. A parallel plate capacitor has a capacitance C . The area of each plate is A . What would be the area of each plate need to be in order to double the capacitance?

(A) $2A$

Correct. The capacitance is doubled when the plate areas are doubled.

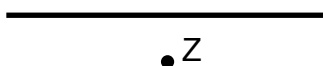
(B) $4A$

Incorrect. The capacitance is doubled when the plate areas are doubled.

(C) A

Incorrect. The capacitance is doubled when the plate areas are doubled.

28. A current of positive charge is flowing in the wire shown below. The direction of the magnetic field at point Z is out of the page. What direction is the current flowing?



(A) To the left.

Correct. The direction of the current is to the left.

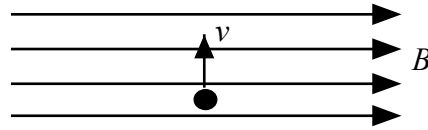
(B) To the right.

Incorrect. The direction of the current is to the left.

(C) Insufficient data to make a determination.

Incorrect. The direction of the current is to the left.

29. An electron with a velocity v moves perpendicular to a magnetic field B as shown in the diagram below. What is the direction of the magnetic force that acts on the electron?



(A) To the left.

Incorrect. It is out of the page.

(B) To the right.

Incorrect. It is out of the page.

(C) Out of the page.

Correct. The direction of the force is out of the page.

30. The wavelength of a radio wave is λ_1 , the wavelength of an infrared wave is λ_2 and the wavelength of visible light wave is λ_3 . Which of the following is true?

(A) $\lambda_1 < \lambda_2 < \lambda_3$

Correct. The wavelength of the radio wave is less than the infrared wave, which is less than the visible light wave.

(B) $\lambda_3 < \lambda_2 < \lambda_1$

Incorrect. The wavelength of the radio wave is less than the infrared wave, which is less than the visible light wave.

(C) $\lambda_1 < \lambda_3 < \lambda_2$

Incorrect. The wavelength of the radio wave is less than the infrared wave, which is less than the visible light wave.

31. Which of the following states the equation of continuity?

(A) Where the velocity of a fluid is low, the pressure is high.

Incorrect. The volume rate of flow (Av) of an incompressible fluid through a pipe of varying diameter is the same at all points along the pipe.

(B) The volume rate of flow (Av) of an incompressible fluid through a pipe of varying diameter is the same at all points along the pipe.

Correct. This is one form of the equation of continuity.

(C) A fluid exerts a pressure in all directions.

Incorrect. The volume rate of flow (Av) of an incompressible fluid through a pipe of varying diameter is the same at all points along the pipe.

32. What determines the pitch of a sound?

(A) Its timbre.

Incorrect. The pitch of a sound is determined by its frequency.

(B) Its beats.

Incorrect. The pitch of a sound is determined by its frequency.

(C) Its frequency.

Correct. The pitch of a sound is determined by its frequency.

Free Response Section [36 pts; 3 pts each]

1. A 6.00 cm diameter water pipe is connected to a second water pipe with a diameter of 4.00 cm. If the flow speed is 0.75 m/s in the first pipe, what is the flow speed in the second pipe? [1 pt answer, 2 pts method]

$$A_1 = \pi r_1^2 = (3.14)(0.030 \text{ m})^2 = 2.83 \times 10^{-3} \text{ m}^2$$

$$A_2 = \pi r_2^2 = (3.14)(0.020 \text{ m})^2 = 1.26 \times 10^{-3} \text{ m}^2$$

$$A_1 v_1 = A_2 v_2$$

$$v_2 = \frac{A_1 v_1}{A_2} = \frac{(2.83 \times 10^{-3} \text{ m}^2)(0.75 \text{ m/s})}{1.26 \times 10^{-3} \text{ m}^2}$$

Answer : $v_2 = 1.68 \text{ m/s}$

2. A photosensitive metal is illuminated by monochromatic light ($\lambda = 580 \text{ nm}$). If the maximum speed of an emitted photoelectron is $3.0 \times 10^5 \text{ m/s}$, what is the work function of the metal (in joules)? [1 pt answer, 2 pts method]

$$K_{max} = \frac{1}{2} m v^2 = (0.5)(9.11 \times 10^{-31} \text{ kg})(3.0 \times 10^5 \text{ m/s})^2 = 4.1 \times 10^{-20} \text{ J}$$

$$\phi = hf - K_{max} = \frac{hc}{\lambda} - K_{max} = \frac{(6.63 \times 10^{-34} \text{ J} \cdot \text{s})(3.00 \times 10^8 \text{ m/s})}{580 \times 10^{-9} \text{ m}} - (4.1 \times 10^{-20} \text{ J})$$

Answer : $\phi = 3.0 \times 10^{-19} \text{ J}$

3. An electron is accelerated through a potential of 100 V. What is the de Broglie wavelength of the electron? [1 pt answer, 2 pts method]

$$\frac{1}{2} m v^2 = eV$$

$$v = (2eV / m)^{1/2} = ((2)(1.60 \times 10^{-19} \text{ C})(100 \text{ V}) / (9.11 \times 10^{-31} \text{ kg}))^{1/2} = 5.93 \times 10^6 \text{ m/s}$$

$$\lambda = \frac{h}{mv} = \frac{(6.63 \times 10^{-34} \text{ J} \cdot \text{s})}{(9.11 \times 10^{-31} \text{ kg})(5.93 \times 10^6 \text{ m/s})}$$

Answer : $\lambda = 1.23 \times 10^{-10} \text{ m}$

4. A closed organ pipe has a length $L = 70.0$ cm. The speed of sound is approximately 340 m/s at 20° C, and increases by approximately 0.6 m/s for each degree C. What is the fundamental frequency f_1 of the pipe if the air temperature is 0° C? [1 pt answer, 2 pts method]

$$v_0 = (340 \text{ m/s}) - (0.6 \text{ m/s} \cdot \text{deg})(20.0^\circ) = 322 \text{ m/s}$$

$$f_1 = \frac{v_0}{4L} = \frac{322 \text{ m/s}}{(4)(0.700 \text{ m})}$$

$$\text{Answer : } f_1 = 115 \text{ Hz}$$

5. In 1919 Rutherford bombarded nitrogen with alpha particles, resulting in the reaction shown below. What are the atomic number and atomic mass of isotope X? [1 pt answer, 2 pts method]



$$Z = (7 + 2) - 1 = 8$$

$$A = (14 + 4) - 1 = 17$$

$$\text{Answer : Atomic number } Z = 8$$

$$\text{Atomic mass } A = 17$$

6. A heat engine supposedly absorbs 2000 J from a hot reservoir and expels 1000 J to a cold reservoir each cycle, while operating between 550° C and 250° C. Explain why or why not this is theoretically possible? [1 pt answer, 2 pts method]

$$\text{heat engine efficiency : } e = \frac{Q_H - Q_L}{Q_H} = \frac{2000 \text{ J} - 1000 \text{ J}}{2000 \text{ J}} = 0.50$$

$$\text{Carnot efficiency : } e_c = \frac{T_H - T_L}{T_H} = \frac{550^\circ \text{ C} - 250^\circ \text{ C}}{550^\circ \text{ C}} = 0.55$$

Answer : This is theoretically possible because the efficiency of the heat engine(0.50) is less than the ideal Carnot efficiency (0.55).

7. A galaxy is observed to be moving away from our galaxy at a speed of 22 km/s. How many light-years away is the galaxy? ($H_0 = 72 \text{ km/s/Mpc}$ and $1 \text{ pc} = 3.26 \text{ l.y.}$) [1 pt answer, 2 pts method]

$$v = H_0 d$$

$$d = \frac{v}{H_0} = \frac{26.0 \text{ km/s}}{72.0 \text{ km/s/Mpc}}$$

$$d = 0.361 \text{ Mpc} = (3.26 \text{ l.y./pc})(0.361 \times 10^6 \text{ pc})$$

$$\text{Answer: } d = 1.18 \times 10^6 \text{ l.y.}$$

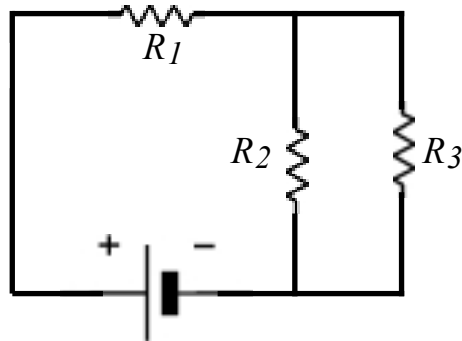
8. After a steel rod is heated from 10.0° C to 90.0° C , its final length is 20.00 m. What was its initial length at 10.0° C ? The coefficient of linear expansion for steel is $12 \times 10^{-6} (\text{C}^\circ)^{-1}$. [1 pt answer, 2 pts method]

$$\Delta L = \alpha L_0 \Delta T = L - L_0$$

$$L_0 = \frac{L}{(1 + \alpha \Delta T)} = \frac{20.00 \text{ m}}{\left(1 + (12 \times 10^{-6} (\text{C}^\circ)^{-1})(80.0^\circ \text{ C})\right)}$$

$$\text{Answer: } L_0 = 19.98 \text{ m}$$

9. Three resistors, R_1 , R_2 and R_3 are connected to a battery as shown in the diagram below. The current through R_2 is 0.20 A and the current through R_3 is 0.35 A. If the resistance of R_1 is 20Ω , then what is the voltage across R_1 ? [1 pt answer, 2 pts method]



$$I_1 = I_2 + I_3 = 0.20 \text{ A} + 0.35 \text{ A} = 0.55 \text{ A}$$

$$V_1 = I_1 R_1 = (0.55 \text{ A})(20 \Omega)$$

$$\text{Answer: } V_1 = 11 \text{ V}$$

10. The pressure on the surface of a research submarine is 2.0×10^7 Pa. The submarine has one window with a diameter of 30 cm. What is the total force exerted on the outside of the submarine's window? [1 pt answer, 2 pts method]

$$P = \frac{F}{A}$$

$$F = PA$$

$$A = \pi r^2 = (3.14)(0.15 \text{ m})^2 = 0.071 \text{ m}^2$$

$$F = (1.8 \times 10^7 \text{ Pa})(0.071 \text{ m}^2)$$

$$\text{Answer : } F = 1.3 \times 10^5 \text{ N}$$

11. An alpha particle has a mass $m = 6.68 \times 10^{-27}$ kg, and it has a charge q that is twice that of a proton. It moves horizontally in a circle of radius $r = 5.0$ cm in a uniform magnetic field $B = 0.15$ T. What is the alpha particle's speed? [1 pt answer, 2 pts method]

$$q = (2)(1.60 \times 10^{-19} \text{ C}) = 3.20 \times 10^{-19} \text{ C}$$

$$qvB = \frac{mv^2}{r}$$

$$v = \frac{rqB}{m} = \frac{(5.0 \times 10^{-2} \text{ m})(3.20 \times 10^{-19} \text{ C})(0.15 \text{ T})}{6.68 \times 10^{-27} \text{ kg}}$$

$$\text{Answer : } v = 3.59 \times 10^5 \text{ m/s}$$

12. A flat glass plate has uniform layer of alcohol on it. The index of refraction of the glass is 1.46, and that of the alcohol is 1.36. A beam of light goes through the alcohol and strikes the glass at an angle of 44.0° relative to the normal. What is the angle of a light ray, relative to the normal, when it enters the glass? [1 pt answer, 2 pts method]

$$\sin \theta_{\text{glass}} = \frac{n_{\text{alcohol}} \sin \theta_{\text{alcohol}}}{n_{\text{glass}}}$$

$$\theta_{\text{glass}} = \sin^{-1} \theta_{\text{glass}} = \sin^{-1} \left(\frac{(1.36) \sin(44.0^\circ)}{(1.46)} \right)$$

$$\text{Answer : } \theta_{\text{glass}} = 40.3^\circ$$