

Constants and Formulae for the Physics 2010 Final Exam

Useful Constants

k_B	$= R/N_A = 1.381 \times 10^{-23} \text{ J/K}$	R	$= 8.314 \text{ J/(K}\cdot\text{mol)}$
m_H	$= 1.673 \times 10^{-27} \text{ kg}$	σ	$= 5.67 \times 10^{-8} \text{ W/(m}^2\cdot\text{K}^4)$
G	$= 6.673 \times 10^{-11} \text{ N m}^2 / \text{kg}^2$	g	$= 9.80 \text{ m/s}^2$
N_A	$= 6.023 \times 10^{23} \text{ molecules/mole}$	1 cal	$= 4.187 \text{ J}$
$M_\oplus$	$= 5.9763 \times 10^{24} \text{ kg}$	$K_\oplus$	$= 9.90 \times 10^{-14} \text{ s}^2/\text{m}^3$
1 mm	$= 10^{-3} \text{ m}$	1 cm	$= 10^{-2} \text{ m}$
1 km	$= 10^3 \text{ m}$	1 liter	$= 10^{-3} \text{ m}^3$
1 hr	$= 3600 \text{ s}$	1 day	$= 8.64 \times 10^4 \text{ s}$
1 yr	$= 365.242 \text{ days}$	1 kPa	$= 10^3 \text{ Pa}, \quad 1 \text{ kJ} = 10^3 \text{ J}$
$P_\circ$	$= 1.013 \times 10^5 \text{ Pa} = 1.00 \text{ atm}$	1 Pa	$= 1 \text{ N} / \text{m}^2$

Useful Geometry and Trigonometry Formulae

$$A \text{ (circle)} = \pi r^2$$

$$V \text{ (sphere)} = \frac{4}{3}\pi r^3$$

$$V \text{ (cylinder)} = A \ell$$

$$\Delta V \text{ (cylinder)} = A \Delta x$$

$$\sin \theta = \text{opposite} / \text{hypotenuse}$$

$$\cos \theta = \text{adjacent} / \text{hypotenuse}$$

$$\tan \theta = \text{opposite} / \text{adjacent}$$

$$r^2 = x^2 + y^2$$

$$v_x = v \cos \theta$$

$$v_y = v \sin \theta$$

$$\tan \theta = \frac{v_y}{v_x}$$

$$v = |\vec{v}| = \sqrt{v_x^2 + v_y^2}$$

Useful Physics Formulae

$$v = \Delta x / \Delta t$$

$$a = \Delta v / \Delta t$$

$$v_x = v_{ox}$$

$$x = x_o + v_{ox}(t - t_o)$$

$$v_y = v_{oy} - g(t - t_o)$$

$$y = y_o + v_{oy}(t - t_o) - \frac{1}{2}g(t - t_o)^2$$

$$v_y^2 = v_{oy}^2 - 2g(y - y_o)$$

$$v = \sqrt{v_x^2 + v_y^2}$$

$$\Sigma \vec{F} = m\vec{a}$$

$$\vec{F}_g = \vec{w} = m\vec{g}$$

$$W = (F \cos \theta)s$$

$$\text{KE} = \frac{1}{2}mv^2$$

$$\text{PE}_g = mgy$$

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

$$\omega = \omega_o + \alpha(t - t_o)$$

$$1 \text{ rev} = 2\pi \text{ radians} = 360^\circ$$

$$\theta = \theta_o + \omega_o(t - t_o) + \frac{1}{2}\alpha(t - t_o)^2$$

$$\omega^2 = \omega_o^2 + 2\alpha(\theta - \theta_o)$$

$$\vec{F}_g = (Gm_1m_2/r^2)\hat{r}$$

$$\text{TE} = 3k_B T/2$$

$$T^2 = K_\oplus a^3 = K_\oplus r^3$$

$$v_{\text{orb}} = \sqrt{GM/r}$$

$$\tau = Fd = I\alpha$$

$$L = I\omega$$

$$\text{KE}_r = \frac{1}{2}I\omega^2$$

$$P = F/A$$

$$P = \rho k_B T / (\mu m_H) = Nk_B T$$

$$PV = nRT, \quad P \Delta V = nR \Delta T$$

$$\rho = m/V = \mu m_H N$$

$$P = P_o + \rho gh$$

$$P_1 V_1 = P_2 V_2$$

$$V_1/T_1 = V_2/T_2$$

$$T_F = \frac{9}{5}T_C + 32$$

$$T_C = T - 273.15$$

$$Q = mc\Delta T$$

$$Q = mL$$

$$Q_{\text{gain}} = Q_{\text{loss}}$$

$$C_v = 3R/2, \quad C_p = 5R/2$$

$$v_{\text{rms}} \equiv \sqrt{v^2} = \sqrt{\frac{3k_B T}{m}}$$

$$\frac{3}{2}k_B T = \frac{1}{2}m\overline{v^2}$$

$$\Delta U = Q + W$$

$$\Delta W = W = -F \Delta x = -P \Delta V$$

$$e = 1 - |Q_C|/|Q_H| = 1 - T_C/T_H$$

$$\Delta S = Q/T$$

Final (A) – 8 December 2025

Part A: Hard Multiple Choice (20 points total, 2 points each). Circle the best answer.

1. A vector has a component of -8 in the x direction and a component of +11 in the y direction. The magnitude of this vector is:

- a) zero b) 3.0 c) 7.5 d) 13.6 e) 19.0

2. A 26.9 kg ball is at rest and experiences a force on it for 3.22 s. During this time, it accelerates at 20.06 m/s^2 . What is the magnitude of the force that acted on this ball?

- a) 0.00 N b) 12.2 N c) 20.1 N d) 86.6 N e) 540 N

3. When compressed by 0.500 m, a spring has the same potential energy as a 50.0 kg ball at a height of 1.00 m above the ground. What is the spring constant of this spring?

- a) 0.193 kg/s^2 b) 5.11 N/m c) 3920 N/m
d) 6.88 J/m^2 e) 4.56 kg/s^2

4. A wheel starts rotating from rest with angular acceleration of 0.426 rad/s^2 . How many revolutions does it turn in 10.0 seconds?

- a) 21.3 b) 1220 c) 32.4 d) 31.4 e) 3.39

5. A 5.00 kg wrench is rotated about a nut such that its lever arm is 50.0 cm. If the force exerted on the wrench is 150 N, what is the torque on the wrench?

- a) 250 M m b) 300 N m c) 86.2 N m d) 75.0 N m e) 2.55 N m

6. What is the work done on a cylinder of 1.00 atm of air that is compressed such that the cylinder's volume changes by -0.50 m^3 ?

- a) 0.5 J b) $5.1 \times 10^5 \text{ W}$ c) $1.0 \times 10^5 \text{ N}$
d) $5.1 \times 10^4 \text{ J}$ e) $-5.1 \times 10^5 \text{ J}$

7. Ideal gas in a 2.66 liter cylinder has a pressure of 2.44 atm. If the cylinder is compressed isothermally to a new volume of 1.86 liter, what will be the pressure of this gas?

- a) 2.66 atm b) 3.49 atm c) 4.01 atm d) 4.95 atm e) 6.49 atm

8. A 6.98 liter container contains 2.44 mol of an ideal gas. What is the molar specific heat at constant pressure for this gas?

- a) $8.314 \text{ J}/(\text{K}\cdot\text{mol})$ b) $12.47 \text{ J}/(\text{K}\cdot\text{mol})$ c) $20.79 \text{ J}/(\text{K}\cdot\text{mol})$
d) $24.94 \text{ J}/(\text{K}\cdot\text{mol})$ e) $41.57 \text{ J}/(\text{K}\cdot\text{mol})$

9. The deepest layers of the solar atmosphere has 1.57×10^{23} particles per cubic meter at a mass density of $3.29 \times 10^{-4} \text{ kg}/\text{m}^3$, what is the mean molecular weight of the gas at these depths in the solar atmosphere?

- a) 891 N/kg b) 42.3 N/kg c) 4.98 d) 2.10 e) 1.25

10. A 3.78 liter container of an ideal gas is at pressure of $2.56 \times 10^5 \text{ Pa}$ and a temperature of 368 K. How many moles of gas are in this container?

- a) 0.316 mol b) 1.02 mol c) 3.22 mol d) 10.2 mol e) 21.8 mol
-

Part B: Easy Multiple Choice (20 points total, 1 point each). Circle the best answer.

11. We have determined an algebraic formula for a final velocity of $v = Ar + B/t^3$ (r is position, t is time, and A, B are constants). What are the dimensions of B ?

- a) m/s^3 b) s^2 c) kg m s d) m/s e) m s^2

12. For projectile motion, the path is always:

- a) linear b) exponential c) hyperbolic d) parabolic e) paved

13. The theory of gravity is a theory because:

- a) Newton said so.
b) its model was the simplest.
c) its equations are known by all scientists.
d) it has been validated through repeated experiments.
e) none of the above

14. Newton's 3rd law of motion can also be expressed as the

- a) newton b) angular displacement c) conservation of linear momentum
d) tangential speed e) conservation of energy

15. The equation $W_{\text{net}} = \frac{1}{2}m(v^2 - v_o^2)$ is better known as the

- a) work–energy theorem b) conservation of momentum c) Tom Servo
d) angular displacement e) conservation of energy

16. If a body spins on an axis, it is said to be

- a) revolving b) rotating c) accelerating d) in orbit e) drunk

17. The measure of matter's resistance to change in motion is better known as

- a) moment of inertia b) conduction c) acceleration
- d) voltage e) none of these

18. When all particles in an object have come to a *complete* stop, what is said to have occurred?

- a) the object boils b) the object evaporates c) the object sublimates
- d) $T = 0$ K e) the object ionizes

19. If the temperature of an object is constant throughout its interior, what is true about the object?

- a) it's in hydrostatic equilibrium
- b) it's in thermal equilibrium
- c) it's in static equilibrium
- d) it's in statistical equilibrium
- e) none of these

20. Which of the following state variables is a measure of how much heat is unavailable for conversion into work?

- a) pressure b) temperature c) Helmholtz free energy
- d) enthalpy e) entropy

21. When a final state can be returned to its initial state, the process is called

- a) irreversible b) reversible c) isothermal d) adiabatic e) isobaric

22. Linear elasticity is also known as

- a) Young's modulus b) shear modulus c) bulk modulus
- d) Carl e) compressibility

23. Which of the following does not describe an ideal gas?

- a) The gas is isothermal.
- b) The molecules obey Newton's laws of motion, but as a whole they move randomly.
- c) The molecules interact only by short-range forces during elastic collisions.
- d) The molecules make elastic collisions with the walls.
- e) The gas is homogeneous.

24. The general form of the first law of thermodynamics is nothing more than the conservation of

- a) momentum b) angular momentum c) mass
- d) energy e) entropy

25. The *constant temperature* gas law is referred to as whose law?

- a) Charles' b) Boyle's c) Gay-Lussac's d) Hoyle's e) Kepler's

26. A body in hydrostatic equilibrium has the following characteristic:

- a) A body absorbs and emits energy at the same rate.
- b) A body is in local thermodynamic equilibrium.
- c) A body is at the same temperature as its surroundings.
- d) The entropy of a body remains constant.
- e) The internal pressure of a gaseous layer is balanced by the weight of the layers on top.

27. The ratio of the work done by a system to the heat input is called

- a) coefficient of performance b) entropy c) enthalpy
- d) thermal efficiency e) Homer

28. Which of the following laws deals with a description of change in nature?

- a) Newton's 1st Law
- b) Newton's 3rd Law
- c) Kepler's 1st Law
- d) 1st Law of Thermodynamics
- e) 2nd Law of Thermodynamics

29. Which of the following state variables is a measure of how much heat is available for conversion into work?

- a) pressure
- b) temperature
- c) Helmholtz free energy
- d) enthalpy
- e) entropy

30. What is the last name of the instructor in this course?

- a) Einstein
 - b) Newton
 - c) Galilei
 - d) Luttermoser
 - e) Dhar
-

Part C: Problems (40 points total, 10 points each).

31. A golfer hits a golf ball from the ground at a velocity of 72.2 m/s with a projection angle of 36.2° . (a) How high will the golf ball reach? (b) How long will it take to get to this maximum height? (c) How far downrange does it travel before it hits the ground? (**Show all work including a diagram!**)

32. Assume that the Moon is in circular orbit about the Earth. It takes the Moon 27.32 days to circle the Earth once with respect to the background stars (*i.e.*, its orbital period). (a) What is the orbital radius of the Moon (in km)? (b) What is the orbital velocity of the Moon (in km/s)? (c) If the gravitational force between the Earth and the Moon is 1.98×10^{20} N, what is the mass of the Moon? (See the *Useful Constants* table for constants needed for this problem. **Show all work!**)

33. CO₂ gas in a cylinder of radius 28.2 cm is compressed by a piston isobarically at 1.68 atm. From its initial position to its final position the piston moves 10.8 cm. During this compression, 1270 J of energy leaves the gas by heat. (a) What is the work done *on* the gas? (b) What is the change in its internal energy? (c) Assuming the gas is ideal, what is the change in temperature if there are 2.64 mol of CO₂ in this container? (**Show all work!**)

34. A melting block of ice experiences a change in entropy of 28.2 kJ/K while it completely melts. (a) What is the weight of the ice block? (b) How many calories of heat were required to melt this ice block? (Note that the latent heat of fusion of water is $3.34 \times 10^5 \text{ J/kg}$, the latent heat of vaporization of water is $2.26 \times 10^6 \text{ J/kg}$, and the specific heat of water is $4186 \text{ J/(kg}\cdot^\circ\text{C)}$). *Hint:* Water melts at 0°C . **Show all work!**)

Extra Credit Problem (10 points, 5 points each — do this only if you have time).

35. The moment of inertia of a disk spinning about its center is 82.0 kg m^2 . The radius of this disk is 2.52 m . Starting from rest, a force is applied tangentially to its circumference for 16.2 seconds , producing a torque of 182 N m . (a) At what angular acceleration does the disk rotate during this time period? (b) What is its angular speed at 16.2 seconds ? (**Show all work!!!**)
36. The root-mean-square velocity of a monatomic gas is 1.22 km/s . If the gas is at a temperature of 122 C° , what is the mass of the gas particles?