

Physics 2010 Exam 3 Constants and Formulae

Useful Constants

$$G = 6.673 \times 10^{-11} \text{ N m}^2 / \text{kg}^2 \qquad c = 3.00 \times 10^8 \text{ m/s}$$

$$\sigma = 5.6696 \times 10^{-8} \text{ W/m}^2/\text{K}^4 \qquad g = 9.80 \text{ m/s}^2$$

$$1 \text{ mm} = 10^{-3} \text{ m} \qquad 1 \text{ cm} = 10^{-2} \text{ m} = 10 \text{ mm}$$

$$1 \text{ km} = 10^3 \text{ m} \qquad 1 \text{ liter} = 10^{-3} \text{ m}^3$$

$$1 \text{ kg} = 10^3 \text{ gram} \qquad 1 \text{ W} = 1 \text{ J/s}$$

$$1 \text{ min} = 60 \text{ s} \qquad 1 \text{ hr} = 3600 \text{ s}$$

$$1 \text{ Pa} = 1 \text{ N} / \text{m}^2 \qquad P_{\circ} = 1.013 \times 10^5 \text{ Pa}$$

Useful Geometry and Physics Formulae

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

$$A \text{ (circle)} = \pi R^2 = \frac{\pi}{4}D^2$$

$$R = D/2$$

$$A \text{ (sphere)} = 4\pi R^2$$

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

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

$$\text{KE}_t \equiv \frac{1}{2}mv^2$$

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

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

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

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

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

$$w_{\text{eff}} = mg \left(1 - \frac{\rho_f}{\rho_o}\right)$$

$$Y = \frac{FL_o}{A \Delta L}$$

$$\tau = F d = I\alpha$$

$$L = I\omega$$

$$P = \rho gh$$

$$P = P_o + \rho gh$$

$$P = F/A$$

$$\rho = M/V$$

$$\Delta Q = \mathcal{P} \Delta t$$

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

$$\text{Mass flux} = \rho Av$$

$$\text{Flow rate} = Av$$

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

$$T_C = T - 273.15$$

$$\Delta L = \alpha L_o \Delta T$$

$$\alpha = \Delta\omega / \Delta t$$

$$\Delta Q = Q = mc \Delta T$$

$$\Delta Q = Q = mL$$

$$\mathcal{P}_{\text{cond}} = \Delta Q / \Delta t = KA(T_2 - T_1)/L$$

$$\mathcal{P}_{\text{em}} = \sigma A e T^4$$

Exam 3A – November 13, 2024

Part A: Hard Multiple Choice (10 points total, 2 points each). Circle best answer.

1. A disk is rotating about an axis through its center. If its angular momentum is $220 \text{ kg m}^2/\text{s}$ and its moment of inertia is 12.2 kg m^2 , what is its angular speed?

- a) 12.2 rad/s b) 5.54 cm/s c) 220 cm/s d) 220 rad/s e) 18.0 rad/s

2. A 15.0 kg wrench is moved with a force of 320 N which produces a torque of 102 N m . What is the lever arm of this wrench?

- a) 21.3 m/s^2 b) 31.9 cm c) 15.0 cm d) 3.14 m e) 6.8 m

3. Brass has a Young's modulus of $9.10 \times 10^{10} \text{ Pa}$. If a brass rod of cross-sectional area of $1.20 \times 10^{-3} \text{ m}^2$ has a change of length of 0.16 mm from its original length of 1.20 m , how much force is being exerted on it?

- a) 1.24 Pa b) 50.0 N c) $1.46 \times 10^4 \text{ N}$
d) 12.4 Pa e) 2540 N

4. At what temperature (in $^{\circ}\text{C}$) is absolute zero (*i.e.*, 0 K)?

- a) zero b) -459.67 c) 303.45 d) -273.15 e) 233.15

5. A metal bar has a specific heat of $212 \text{ J}/(\text{kg}\cdot^{\circ}\text{C})$. If its temperature increases by 32.6°C when 52.1 kJ of heat is applied to this bar, what is the mass of this bar?

- a) 0.246 kg b) 6.50 kg c) 7.54 kg d) 133 kg e) 6910 kg
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Part B: Easy Multiple Choice (10 points total, 1 point each). Circle best answer.

6. A body in thermal equilibrium has an emissivity of exactly 1.00. Such a body is called a

- a) blackbody b) whitebody c) projectile
- d) streamline e) quark

7. Devices used to measure temperature are called

- a) thermometers b) calorimeters c) ergometers
- d) barometers e) none of these

8. What types of solids have their atoms and molecules arranged in a random fashion?

- a) crystalline b) amorphous c) opaque
- d) dark e) bright

9. The mixing-length theory is often used to approximate the process of

- a) conduction b) convection c) radiation transport
- d) melting e) freezing

10. Which of the following laws describes the relationship between viscosity and pressure in a pipe?

- a) Continuity b) Bernoulli c) Poiseuille
- d) Archimedes e) Pascal

11. The inverse of the bulk modulus of an object is called its

- a) Young's modulus b) luminosity c) shear modulus
- d) capacitance e) compressibility

12. Which of the following is not considered to be a characteristic of an ideal fluid?

- a) Fluid has a constant density throughout its volume.
- b) Fluid has a constant pressure throughout its volume.
- c) Fluid is not accelerating.
- d) Fluid has no angular velocity.
- e) Fluid has no internal friction.

13. When the flow of a fluid has a non-zero angular velocity, the flow is said to be

- a) Reynolds b) turbulent c) hypersonic
- d) laminar e) relativistic

14. The COBE spacecraft measured the temperature of the microwave background radiation of the Big Bang to be 2.73 K on one side of the sky and 2.73 K on the direct opposite side of the sky. What must be true about the Universe based upon this statement?

- a) It is not accelerating.
- b) It has a non-zero expansion velocity.
- c) It has a non-zero magnetic field strength.
- d) It is in hydrostatic equilibrium.
- e) It is in thermal equilibrium.

15. Linear acceleration is to angular acceleration as mass is to

- a) torque b) angular speed c) moment of inertia
 - d) force e) weight
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Part C: Problems (20 points total, 10 points each).

16. A disk has a moment of inertia of $I = \frac{1}{2}MR^2 = 562 \text{ kg}\cdot\text{m}^2$ and a diameter of 4.00 m. It starts rotating from rest at a constant angular acceleration of 0.246 rad/s^2 . (a) What is the weight of this disk? (b) What force must the motor be supplying to this disk to get it to rotate at this angular acceleration? (Assume the motor is attached to the circumference of the disk.) (c) What is the rotational kinetic energy of this disk after it has been moving for 1.50 minutes? (**Show all work!**)

17. A 32.6 kg piece of metal is heated to a temperature 216 °C. It is then immediately dropped into a container of water which is at a temperature of 18.2 °C. The water fills a volume of 2.22 liters (li). When equilibrium is reached, the water and the metal are both at a temperature of 62.2 °C. (a) What is the mass of the water? (b) What is the specific heat of this piece of metal? (Note that the density of water is 1000 kg/m³ and the specific heat of water is 4186 J/(kg · °C).) (**Show all work!**)

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

18. A spherical object has a radius of 9.66 m and a temperature of 1120 K. This object shines with an emitted power of 7.97×10^7 W. What is the emissivity of this object? (**Show all work!**)