

# Physics 2010 Exam 3 Constants and Formulae

## Useful Constants

$G$	$= 6.673 \times 10^{-11} \text{ N m}^2 / \text{kg}^2$	$c$	$= 3.00 \times 10^8 \text{ m/s}$
$\sigma$	$= 5.6696 \times 10^{-8} \text{ W/m}^2/\text{K}^4$	$g$	$= 9.80 \text{ m/s}^2$
1 mm	$= 10^{-3} \text{ m}$	1 cm	$= 10^{-2} \text{ m} = 10 \text{ mm}$
1 km	$= 10^3 \text{ m}$	1 mi	$= 5280 \text{ ft}$
1 mi	$= 1.609 \text{ km}$	1 A.U.	$= 1.496 \times 10^{11} \text{ m}$
1 min	$= 60 \text{ s}$	1 hr	$= 3600 \text{ s}$
1 day	$= 8.64 \times 10^4 \text{ s}$	1 yr	$= 365.242 \text{ days}$
1 Pa	$= 1 \text{ N} / \text{m}^2$	$P_{\circ}$	$= 1.013 \times 10^5 \text{ Pa}$

## Useful Geometry and Trigonometry Formulae

$$\begin{aligned} V (\text{sphere}) &= \frac{4}{3}\pi R^3 & A (\text{circle}) &= \pi R^2 = \frac{\pi}{4}D^2 \\ A (\text{sphere}) &= 4\pi R^2 & \cos \theta &= b/c \\ \tan \theta &= a/b & \sin \theta &= a/c \\ 1 &= \cos^2 \theta + \sin^2 \theta & c^2 &= a^2 + b^2 \end{aligned}$$

In the trigonometric equations above,  $a \equiv$  opposite side,  $b \equiv$  adjacent side, and  $c \equiv$  hypotenuse where the angle is  $\theta$ .

## Useful Physics Formulae

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

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

$$s = \theta r$$

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

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

$$\tau = Fd$$

$$(\text{KE}_t + \text{KE}_r + \text{PE})_i = (\text{KE}_t + \text{KE}_r + \text{PE})_f$$

$$x_{cg} = \frac{\Sigma m_i x_i}{\Sigma m_i}$$

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

$$\tau = I\alpha = \Delta L / \Delta t$$

$$P = \rho gh$$

$$P = F/A$$

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

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

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

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

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

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

$$\mathcal{P}_{\text{net}} = P_{\text{em}} - \mathcal{P}_{\text{abs}} = \sigma A e (T^4 - T_o^4)$$

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

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

$$\vec{p} \equiv m\vec{v}$$

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

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

$$I = \Sigma m_i r_i^2$$

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

$$\omega = 2\pi/T$$

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

$$L = I\omega$$

$$P = P_o + \rho gh$$

$$\rho = M/V$$

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

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

$$T_C = T - 273.15$$

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

$$\Delta Q = Q = mL$$

$$\mathcal{P}_{\text{bb}} = \sigma AT^4$$

$$F_{\text{bb}} = \sigma T^4$$

**Exam 3A** – 16 November 2009

---

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

1. A disk has a moment of inertia of  $396 \text{ kg}\cdot\text{m}^2$  and a rotational kinetic energy of  $1240 \text{ J}$ . What is the angular speed of this disk?

- a)  $6.26 \text{ rad/s}$                       b)  $2.50 \text{ rad/s}$                       c)  $0.00 \text{ rad/s}$   
d)  $0.639 \text{ rad/s}$                       e)  $0.319 \text{ rad/s}$

2. A  $62.2 \text{ kg}$  mass sits at  $-2.40 \text{ m}$  on the  $x$  axis. A  $16.2 \text{ kg}$  mass sits at  $+6.80 \text{ m}$  on the  $x$  axis. Where does the center of mass lie?

- a)  $0.00 \text{ m}$                       b)  $-0.499 \text{ m}$                       c)  $1.30 \text{ m}$                       d)  $4.60 \text{ m}$                       e)  $-39.2 \text{ m}$

3. Consider a faucet that delivers water into a sink with a drain. Because of a clog, water drains at  $1.0 \text{ cm/s}$  through an area of  $0.003 \text{ m}^2$ . What is the mass flux of water through the drain? (*Hint:* The density of water is  $1000 \text{ kg/m}^3$ .)

- a)  $0.03 \text{ kg/s}$                       b)  $0.3 \text{ kg/s}$                       c)  $3. \text{ kg/s}$                       d)  $30 \text{ kg/s}$                       e)  $300 \text{ kg/s}$

4. A comfortable room temperature might be  $22.5^\circ\text{C}$ . What is this temperature in Kelvin?

- a)  $22.5 \text{ K}$                       b)  $54.5 \text{ K}$                       c)  $72.5 \text{ K}$                       d)  $250.6 \text{ K}$                       e)  $295.7 \text{ K}$

5. An unknown frozen substance with a latent heat of fusion of  $2440 \text{ J/kg}$  has just started to melt. If we apply  $3.46 \times 10^6 \text{ Joules}$  of heat to this icy substance, it will completely melt to liquid. What is the mass of this unknown substance?

- a)  $0.705 \text{ gm}$                       b)  $133 \text{ kg}$                       c)  $1420 \text{ kg}$                       d)  $6520 \text{ kg}$                       e)  $8.44 \times 10^9 \text{ kg}$
-

**Part B: Easy Multiple Choice (10 points total, 1 point each).** Circle best answer.

6. During a phase change, such as when steam condenses to form droplets,

- a) heat exchange leads to a temperature increase.
- b) heat exchange leads to a temperature decrease.
- c) heat exchange drives the phase change.
- d) heat exchange changes the mass of the substance in question.
- e) there is no heat exchanged.

7. Devices used to measure pressure are called

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

8. The conservation of energy for a fluid is given by the equation of

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

9. The term “absolute zero” refers to

- a) the temperature at which water freezes.
- b) the temperature at which carbon dioxide freezes.
- c) the zero point in the Fahrenheit scale.
- d) the temperature at which all particle motion stops.
- e) the coldest temperature ever achieved on Earth.

10. What types of solids have their atoms and molecules arranged in a orderly fashion?

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

11. *Specific gravity* measures which of the following?

- a) acceleration                      b) density                              c) latent heat  
d) specific heat                      e) heat capacity

12. Objects that have an emissivity of exactly one are called

- a) incompressible                      b) blackbodies                      c) non-viscous  
d) amorphous                              e) non-turbulent

13. If a rotating object obeys the conservation of angular momentum, which of the following must be true?

- a)  $\sum F = 0$                               b)  $\sum E = 0$                               c)  $\sum \tau = 0$   
d)  $E = \eta mc^2$                               e) none of these

14. Who was the first to state that pressure applied to an enclosed fluid is transmitted undiminished to every point of the fluid and to the walls of the containing vessel?

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

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

- a) Young's modulus                      b) angular speed                      c) torque  
d) capacitance                              e) compressibility
-

**Part C: Problems (20 points total, 10 points each).**

16. A spherical asteroid of uniform density of  $3220 \text{ kg/m}^3$  and radius of  $1920 \text{ km}$  is spinning uniformly about an axis completing one revolution in  $2.64 \text{ days}$ . (a) What is the moment of inertia of this spinning sphere? (*Hint:* You will need to figure out the mass from the density equation. The moment of inertia of a uniform sphere spinning about a center axis is  $\frac{2}{5}MR^2$ .) (b) What is the rotational kinetic energy of this sphere? (*Hint:* You will need to figure out angular speed from the rotation rate.) (c) What is the angular momentum of this spinning sphere? (**Show all work. *Hint:* Don't forget to make all units consistent!** Needed geometry and physics equations and unit conversions are located on both sides of the Constants/Equations sheet.)

17. A spherical ball has a mass of 2.66 kg and a radius of 3.34 cm. This ball is suspended from a weight scale. (a) What would be the weight of this ball as measured in the air? (b) What is the volume of this ball in cubic meters? (c) The ball, still suspended from the scale, is now emersed in fresh water. Calculate the effective weight of the ball for this situation. (*Hint:* The density of water is 1000 kg/m<sup>3</sup>. **Show all work and make sure your units are consistent!**)

---

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

18. A metal rod has a thermal expansion coefficient of  $6.44 \times 10^{-5} \text{ }^\circ\text{C}^{-1}$ . Initially the rod has a temperature of  $55.6^\circ\text{F}$  at some initial length. The rod is heated to  $412^\circ\text{F}$  which causes it length to change by 3.89 mm. What must have been the initial length of the rod in centimeters? (**Show all work!**)