Physics 2020 Exam 3 Constants and Formulae

Useful Constants

k_e	=	8.99×10^9 N m^2/C^2	e	=	1.60219×10^{-19} C
$\hbar$	=	$h/2\pi = 1.05459 \times 10^{-34}$ J s	h	=	6.62620×10^{-34} J s
m_p	=	$m_{\rm H} = 1.672 \times 10^{-27}$ kg	m_e	=	9.110×10^{-31} kg
c	=	2.997925×10^8 m/s	$R_\odot$	=	6.96×10^8 m
σ	=	5.6696×10^{-8} W/m^2/K^4	$T_\odot$	=	5770 K
g	=	9.80 m/s^2	1 kg	=	1000 gram
$I_{\rm th} = I_\circ$	=	1.00×10^{-12} W/m^2	$I_{\rm tp}$	=	1.00 W/m^2
1 eV	=	1.60219×10^{-19} J	1 mA	=	10^{-3} A
1 km	=	10^3 m	1 nm	=	10^{-9} m
1 Å	=	10^{-10} m	1 cm	=	10^{-2} m

Note that

$$x = \log y \quad \Longleftrightarrow \quad y = 10^x$$

and

$$x = \ln y \quad \Longleftrightarrow \quad y = e^x$$

where base $e = 2.71828...$

Useful Formulae

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

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

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

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

$F_e = k_e\,|q_1|\,|q_2|/r_{12}^2$

$\mathrm{PE}_e = k_e\,q_1\,q_2/r$

$F_s = -kx$

$E = \mathrm{KE} + \mathrm{PE}$

$T = 1/f = 2\pi\sqrt{m/k}$

$T = 2\pi\sqrt{L/g}$

$\beta = 10\log(I/I_\circ)$

$I = \mathcal{P}/(4\pi r^2)$

$v = \sqrt{Y/\rho} = \sqrt{B/\rho}$

$v = \Delta x/\Delta t$

$v = (331.3\ \mathrm{m/s})\sqrt{T/273\ \mathrm{K}} = f\lambda$

$v = \sqrt{F/\mu}, \quad \mu = m_w/L$

$L = (n/2)\lambda$

$f_n = nf_1$

$\Delta\lambda/\lambda_\circ = (\lambda - \lambda_\circ)/\lambda_\circ = v_r/c$

$\lambda\,\nu = c$

$E = h\nu = hc/\lambda$

$F = \sigma T^4$

$\lambda_{\max} = (2.897 \times 10^{-3}\ \mathrm{m\ K})/T$

$r_n = n^2\ \ (0.0529\ \mathrm{nm})$

$L = 4\pi\sigma R^2 T^4$

$v_n = \sqrt{\dfrac{k_e e^2}{m_e r_n}}$

Physics 2020-002

Name: _____

Exam 3A – 3 April 2017

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

1. A spring with a spring constant of 2.34×10^4 N/m experiences a 246 N force in the negative x direction. How far from the equilibrium position has the spring been stretched?

a) 1.05 cm b) –0.951 cm c) 2.34 mm d) –2.46 mm e) –57.6 mm

2. We measure the energy of a photon to be 8.660 eV. At what wavelength would we observe this photon?

a) 912.0 nm b) 1216 Å c) 1432 Å d) 6563 Å e) 5.67 μm

3. A 2.66 m long metal rod has a Young's modulus of 1.10×10^{11} Pa. If we tap one end of this rod with a hammer, we measure the velocity of the sound wave in the rod to be 3510 m/s. What is the density of this rod?

a) 1320 kg/m^3 b) 3290 kg/m^3 c) 6540 kg/m^3

d) 8930 kg/m^3 e) 9340 kg/m^3

4. A spectral line is observed in the lab at 5822.2 Å, however we observe this line in a star's spectrum at 5836.6 Å. What is the radial (*i.e.*, line-of-sight) velocity of this star?

a) 13.253 km/s b) 36.789 km/s c) 58.222 km/s

d) –73.965 km/s e) 74.147 km/s

5. A concert spectator hears a middle-C note at an intensity of 0.0224 W/m^2. What is the decibel level of this sound?

a) 224 dB b) 120 dB c) 104 dB d) 32.6 dB e) -16.5 dB

Part B: Easy Multiple Choice (10 points total, 1 point each, Circle Best Answer).

6. Who was the first person to state in a mathematical equation that there are no magnetic monopoles?

a) Ampere b) Watt c) Einstein d) Maxwell e) Faraday

7. Particles with half-integer spins (*i.e.*, 1/2, 3/2, ...) are called

a) bosons b) electrons c) quarks d) fermions e) leptons

8. Which of the following is not true about electromagnetic radiation?

a) it has momentum

b) it has energy

c) it propagates in the Ether

d) it's composed of photons

e) it has wave characteristics

9. A wave whose oscillation is perpendicular to the direction of its motion is what type of wave?

a) transverse b) longitudinal c) harmonic

d) audible e) ultrasonic

10. Which of these regions in the electromagnetic spectrum has the longest wavelengths?

a) gamma b) microwave c) ultraviolet d) visual e) X-ray

11. The method of transforming electrical energy into mechanical energy via crystals is called which effect?

a) Doppler b) Lorentz c) piezoelectric d) Wien e) Coriolis

12. The filament in a light bulb when lit is hot and opaque. What kind of spectrum does it produce?

a) absorption line b) continuous c) emission line

d) reflection e) transparent

13. An object emits a blackbody spectrum. What must be true about this object?

a) It is in radiative equilibrium.

b) It is in convective equilibrium.

c) It is in hydrostatic equilibrium.

d) It is in thermal equilibrium.

e) It is <u>not</u> in equilibrium.

14. What are the names of particles made up of quark-antiquark pairs?

a) mesons b) photons c) baryons d) fermions e) leptons

15. A bound electron absorbs a photon, stays excited for a short period of time, then cascades back down to a lower energy level emitting a photon in a random direction. This process is known as

a) inductance b) absorption c) ionization

d) capacitance e) scattering

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

16. A 2.12 kg mass is connected to a spring. The other end of the spring is connected to a wall. This mass is free to oscillate on a frictionless horizontal surface. If this mass is pulled out a certain distance from its equilibrium position and released from rest, it is found to oscillate about this equilibrium position with a period of 3.62 s. When moving at its fastest speed, its velocity is 3.78 m/s. (a) What is the spring constant of the spring? (b) What is the total energy of this oscillating mass? (c) When it was released, how far from the equilibrium position was this mass? (**Show all work!!!**)

17. Assume that we observe an isothermal (*i.e.*, constant temperature throughout the interior) spherical cloud of hydrogen gas of radius 5.79 m. At a distance of ten times the radius of the cloud, we determine that the continuum energy flux radiating from this cloud is 6.076×10^7 W/m^2. (a) What is the temperature of this gas (in K)? (b) What is the total brightness (*i.e.*, luminosity) of this cloud in units of watts? (c) At what wavelength would the peak brightness be shining (in nm)? (**Show all work!!!**)

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

18. A 14.8 kg mass hangs from a cord near the surface of the Earth. The cord has a length of 2.86 m and a mass of 0.168 kg. (a) What is the tension of the cord? (b) If we pluck this core to set it into oscillation, how fast will a transverse wave move on the cord? (**Show all work!**)