Physics 2020 Constants and Formulae

Useful Constants

k_e	=	8.99×10^9 N m^2/C^2	g	=	9.80 m/s^2
G	=	6.673×10^{-11} N m^2 / kg^2	e	=	1.602×10^{-19} C
h	=	6.626×10^{-34} J s	m_p	=	1.672×10^{-27} kg
c	=	3.00×10^8 m/s	m_e	=	9.110×10^{-31} kg
I_{th}	=	1.00×10^{-12} W/m^2	I_{tp}	=	1.00 W/m^2
1 eV	=	1.602×10^{-19} J	1 cm	=	10^{-2} m
1 MeV	=	10^6 eV	1 hr	=	3600 s
1 km	=	10^3 m	1 nm	=	10^{-9} m
1 μm	=	10^{-6} m	1 mm	=	10^{-3} m

Useful Formulae

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

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

$x = x_\circ + v_\circ(t - t_\circ) + \frac{1}{2}a(t - t_\circ)^2$

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

$1 = \cos^2\theta + \sin^2\theta$

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

$v = v_\circ + a(t - t_\circ)$

$v^2 = v_\circ^2 + 2a(x - x_\circ)$

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

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

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

$\text{PE}_g = mgy$

$\text{KE}_i + \text{PE}_i = \text{KE}_f + \text{PE}_f$

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

$F_e = k_e|q_1||q_2|/r^2$

$\vec{E} = \vec{F}_e/q$

$|W| = \Delta\text{PE} = q\,\Delta V = q\,E\,d$

$R = R_\circ[1 + \alpha(T - T_\circ)]$

$C = Q/\Delta V$

$\Delta V \approx \mathcal{E} = Ed$

$C_{eq} = \sum C_i$ (parallel)

$1/C_{eq} = \sum(1/C_i)$ (series)

$\Delta V_1 = \Delta V_2 = \Delta V_i = \Delta V$ (parallel)

$Q_1 = Q_2 = Q_i = Q$ (series)

$\Delta V = \sum \Delta V_i$ (series)

$\tau = RC$

$I = \Delta Q/\Delta t = Q/\Delta t$

$C = \kappa C_\circ, \quad C_\circ = \epsilon_\circ\, A/d$

$\Delta V = IR$

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

$r = mv/qB$

$B = \mu_\circ I/(2\pi r)$

$F_s = -kx$

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

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

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

$1/p + 1/q = 1/f$

$n = c/v, \quad n_1\lambda_1 = n_2\lambda_2$

$M = h'/h = -q/p$

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

$r_n = n^2\,(0.0529 \text{ nm})/Z$

$v_n = \sqrt{k_e e^2/(m_e\, r_n)}$

$n_1 \sin\theta_1 = n_2 \sin\theta_2$

$\nu = c/\lambda$

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

$\theta_m = 1.22\,\lambda/D$

$d\sin\theta = m\lambda, \quad m = 0, \pm1, \pm2, \ldots$

$d = 1/N$

$y_{\text{bright}} = (\lambda L/d)\,m$

$y = L\tan\theta$

Physics 2020-002

Name: _____

Final (A) – 5 May 2010

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Part A: Hard Multiple Choice (20 points total, 2 points each, Circle Best Answer).

1. A proton ($q = +e$) 'feels' a force of 1.73×10^{-12} N from another charged particle when it makes a closest approach of 20.0 nm. What is the charge of this other particle?

a) 2.21×10^{-11} C b) 1.60×10^{-19} C c) $1.12\,e$ d) $3.00\,e$ e) $13.6\,e$

2. An alpha particle has a charge of $2.00\,e$. How much work is required to move this alpha particle across a potential difference of 2270 volts?

a) 4.54 keV b) 13.6 eV c) 2.70×10^{-30} J

d) 2.34×10^{-2} J e) 1.07×10^{3} J

3. A parallel-plate capacitor has a capacitance of 124 pF when air exists between its plates and 702 pF when a dielectric exists between its plates. What is the dielectric constant of this dielectric?

a) 0.177 b) 2.44 c) 5.66 d) 13.6 e) 8.70×10^{4}

4. A potential drop of 12.6 V is experienced in a resistor when 2.24 mA of current is flowing through this resistor. What is the resistance of this resistor?

a) 28.2 mΩ b) 5.63 Ω c) 282 Ω d) 5630 Ω e) 9660 Ω

5. A *RC* circuit has a time constant of 0.222 s. If the resistance in this circuit is 988 Ω, was is the capacitance of this circuit?

a) 225 μF b) 219 F c) 2.11 μF d) 0.473 F e) 0.00 F

6. A light beam travels in the air and encounters a glass surface. If the incident angle is 52.7° and the refracted angle is 12.7°, what is the index of refraction of this glass?

a) 1.52 b) 2.65 c) 3.62 d) 4.67 e) 7.98

7. A lens forms an inverted 4.55 cm image of a 1.22 cm erect object. If the image forms 62.2 cm from the lens, how far in front of the lens is the object?

a) 1.75 cm b) 16.7 cm c) 22.2 cm d) 32.6 cm e) 232 cm

8. The index of refraction of 421.0 nm blue light is 1.721. What is the wavelength of light beam if it has an index of refraction of 1.488?

a) 688.2 nm b) 333.6 nm c) 486.9 nm d) 520.2 nm e) 450.9 nm

9. An object is 1.24 m from a lens and its image is 0.345 m from this lens. What is the absolute value of the magnification of this image?

a) 45.6 b) 15.4 c) 3.59 d) 0.888 e) 0.278

10. An object with a height of 4.20 cm sits 46.6 cm from the reflecting side of a plane mirror. Which of the following best describes the image?

a) Virtual image that is 46.6 cm in back of the mirror.

b) Real image with a height of -4.20 cm.

c) Virtual image with a height of -2.10 cm.

d) Real image 46.6 cm in front of the mirror.

e) None of the above.

Part B: Easy Multiple Choice (20 points total, 1 point each, Circle Best Answer).

11. For an ohmic device, as temperature increase, what also must increase?

a) capacitance b) charge c) resistance d) current e) inductance

12. Which of the following devices, by itself, can be used to measure the amount of current flowing through a circuit?

a) voltmeter b) ohmmeter c) capacimeter

d) galvanometer e) calorimeter

13. Kirchhoff's loop rule is nothing more than a conservation of

a) polarization b) conduction c) energy d) momentum e) charge

14. Lightning will occur when what happens?

a) The potential between a cloud and the ground exceeds 13.6 V.

b) An occluded front stalls over water.

c) For every Avagodro's number of electrons in the ground, there is an Avagodro's number+1 neutrons in the cloud.

d) The cloud/ground E-field exceeds the dielectric strength of the air.

e) A coronal mass ejection occurs on the Sun.

15. Who discovered the effect of self-inductance?

a) Faraday b) Lenz c) Maxwell d) Ampere e) none of these

16. Which of the following intensity levels could be heard by humans without suffering damage to the eardrum?

a) -112 dB b) -12.2 dB c) 32 dB d) 150 dB e) 1200 dB

17. We observe 5 different blackbodies and note the type of light that each emit their maximum amount of flux. Of these, which is the hottest?

a) red b) ultraviolet c) green d) infrared e) microwave

18. Any mass that obeys Hooke's law will follow what type of path/motion?

a) parabolic trajectories

b) circular orbits

c) elliptical orbits

d) simple harmonic motion

e) no motion, it remains at rest

19. Which of the following is true about plane waves?

a) They are spherical waves that have traveled a long distance.

b) They increase in power as they cover more distance.

c) They increase in power as they travel from a medium with a lower index of refraction to one with a higher index.

d) Their frequency increase as they travel.

e) They do not exist in nature.

20. What does the *principle of causality* demand?

a) The Universe is determinate — for every effect, there is a cause.

b) The Universe is probabilistic — all future happenings are based in probability.

c) Newtonian mechanics does not accurately describe the workings of nature.

d) Boltzmann thermodynamics does not accurately describe the workings of nature.

e) None of these are correct.

21. Who interpreted a light wave as a series of spherical wavefronts where each point on the circumference of a given wavefront acts as a point source which generates a new spherical wavefront which propagates outward?

a) Einstein b) Planck c) Faraday d) Huygens e) Maxwell

22. Reflection off of a rough surface is known as what kind of reflection?

a) diffuse b) specular c) glossy

d) matte e) shiny

23. The law of refraction also goes by the name of

a) Maxwell's law b) Newton's law c) Coulomb's law

d) Wein's law e) Snell's law

24. Light of different wavelengths being refracted at different angles is an effect known as

a) diffraction b) dispersion c) interference

d) polarization e) scattering

25. The ratio of the speed of light in a vacuum to the speed of light in a material is called the

a) index of refraction b) opacity c) transparency

d) index of reflection e) conductivity

26. A transparent surface with fine parallel lines etched on it causes light to be dispersed when it passes through this surface. Such a device is called a

a) galvanometer b) radiometer c) prism d) lens e) grating

27. Who performed the double slit experiment?

a) Huygens b) Newton c) Lenz d) Young e) Galileo

28. The optical phenomenon known as a *mirage* occurs as a result of what principle of optics?

a) diffraction b) reflection c) refraction

d) interference e) polarization

29. *Newton's Rings* result from what principle from optics?

a) diffraction b) reflection c) refraction

d) interference e) polarization

30. The objective of a reflecting telescope is often called a(n)

a) eyepiece b) primary mirror c) secondary mirror

d) magnifier e) drunk

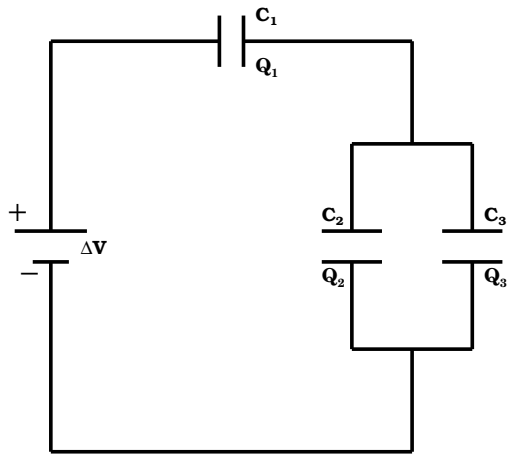
Part C: Problems (40 points total, 10 points each).

31. An object sits to the left of a lens at a distance of 74.2 cm. An inverted image is formed on the right of the lens that is 2.88 times the size of the object. (a) Where is the image formed with respect to the lens (in cm) and is it real or virtual (why)? (b) What is the focal length of the lens (in cm) and is this a diverging or converging lens (why)? (**Show all work!!!**)

32. Monochromatic coherent light is passed through a double slit forming an interference pattern on a screen 82.4 cm from the slits. The separation of the slits is 0.552 mm. A second order bright fringe forms 2.33 mm from the central maximum on the screen. (a) What is the wavelength of this light in nm? (b) At what angle (in acrseconds) would this fringe be located as viewed from a point directly between the two slits? (Note that $1^\circ = 3600$ arcsec. **Show all work!!!**)

33. A doubly-ionized alpha particle ($q = +2e$, $m = 4m_p$) is moving in a uniform parallel electric field in a direction opposite of the electric field. When measurements commence, it has a kinetic energy of 56.4 MeV and it continuously decelerates to a stop. If it moves 6620 km during this time, what is the strength (*i.e.*, absolute value) of the electric field? (**Show all work!!!**)

34. The capacitor circuit in the attached figure has an 18.0 volt battery connected to capacitors with the following capacitance: $C_1 = 24.6\ \mu$F, $C_2 = 14.2\ \mu$F, and $C_3 = 36.2\ \mu$F. (a) Find the equivalent capacitance (in μF) of this circuit. (b) Find the charge (in μC) on each capacitor. (**Show all work and <u>all</u> figures in reducing this circuit!!!**)



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

35. What is the kinetic energy (in eV) of the Balmer-series electron of hydrogen ($Z = 1$)? (**Show all work!**)

36. In the future, a telescope will be launched into space that can just barely resolve the stellar disk of the bright carbon star TX Psc at 1200 nm. If the angular size of TX Psc is 9.31 milli-arcsec, what will be the diameter of this telescope in meters? (Note that $1^\circ = 3600$ arcsec and 'milli' $\equiv 10^{-3}$. **Show all work!!!**)