Physics 2020 Exam 1 Constants and Formulae

Useful Constants

k_e	=	8.99×10^9 N m^2/C^2	$\epsilon_\circ$	=	8.85×10^{-12} C^2/(N m^2)
G	=	6.673×10^{-11} N m^2 / kg^2	e	=	1.602×10^{-19} C
m_p	=	1.672×10^{-27} kg	m_e	=	9.110×10^{-31} kg
c	=	3.00×10^8 m/s	g	=	9.80 m/s^2
1 eV	=	1.602×10^{-19} J	1 amu	=	1.661×10^{-27} kg
1 μ	=	1 micro = 10^{-6}	1 pico	=	10^{-12}
1 km	=	10^3 m	1 mi	=	5280 ft
1 mm	=	10^{-3} m	1 cm	=	10^{-2} m
1 min	=	60 s	1 hr	=	3600 s
1 day	=	8.64×10^4 s	1 yr	=	365.242 days

Useful Formulae

A (circle) $= \pi r^2 = \pi D^2/4$

A (sphere) $= 4\pi r^2$

$\sin\theta =$ (opposite)/(hypotenuse)

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

$\cos\theta =$ (adjacent)/(hypotenuse)

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

$\tan\theta = \sin\theta/\cos\theta =$ (opposite)/(adjacent)

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

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

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

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

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

$\Phi_E = EA\cos\theta = Q_{\text{inside}}/\epsilon_\circ$

$E = k_e q/r^2$

$\mathcal{P} = W/\Delta t = I\ \Delta V = I^2R = (\Delta V)^2/R$

$V = k_e q/r$

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

$V = \sum V_i = k_e \sum(q_i/r_i)$

$R = \rho L/A$

$R = \Delta V/I$

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

$\rho = \rho_\circ[1 + \alpha(T - T_\circ)]$

$C = Q/\Delta V$

$I = \Delta Q/\Delta t$

$C_\circ = \epsilon_\circ A/d$

$C = \kappa C_\circ$

$U = Q^2/(2C) = \frac{1}{2}C(\Delta V)^2 = \frac{1}{2}Q(\Delta V)$

Physics 2020-002

Name: _____

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

1. A plate in a parallel-plate capacitor has a surface area of 2.45×10^{-4} m^2 and a plate separation of 1.88 mm. This capacitor has a dielectric and a capacitance of 5.40 pF. What is the dielectric constant of this dielectric?

a) 1.15×10^{-12} b) 1.15×10^{-3} pF c) 5.40 d) 4.69 e) 120 pF

2. An alpha particle ion with a charge of $+2e$ experiences a force of 2.67×10^{-12} N as it moves through an electric field. What is the strength of the electric field?

a) 8.33×10^{6} N/C b) 3.83×10^{-6} N/C c) 9.11×10^{-12} N/C

d) 1.67×10^{9} N/C e) 1.67×10^{23} N/C

3. When a resistor has 2.33 mA flowing through it, it experiences a voltage drop of 0.112 V. What is the resistance of this resistor?

a) 4.81×10^{-2} Ω b) 0.261 Ω c) 2.33 Ω d) 48.1 Ω e) 102 Ω

4. A proton ($q = e$) experiences an attractive electric force of 2.88×10^{-16} N when it comes to within 16.2 μm of an unidentified particle. What is the charge on this unidentified particle?

a) 1.60×10^{-19} C b) 5.25×10^{-17} C c) 3.24×10^{-12} C

d) 3.28×10^{2} C e) 2.02×10^{7} C

5. A particle produces a potential of 2.88×10^{-4} volts a distance of 0.222 m from the particle. What is the charge on this particle?

a) 7.11×10^{-15} C b) 1.60×10^{-19} C c) $362\,e$

d) $5.66\,e$ e) 8.99×10^{-6} C

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

6. Three capacitors are parallel in a circuit, which of the following must be true?

a) The sum of the charges on each capacitor must equal the charge on the "equivalent" capacitor in the reduced circuit.

b) Each capacitor must have the same charge on it.

c) The sum of the potential drop of each capacitor must equal the voltage gain of the supplying battery.

d) Each capacitor must have the same capacitance.

e) The sum of the reciprocal capacitance on each capacitor must equal the reciprocal capacitance of the "equivalent" capacitor in the reduced circuit.

7. An electron lies on the origin of a Cartesian coordinate system. A helium nucleus ($q = 2e$) lies at -3.2 m on the x axis. A proton lies at +3.2 m on the x axis. Which direction will the electron move?

a) $-x$ b) $+x$ c) $-y$ d) $+y$ e) none of these

8. Assume we have a charged object where electric field lines flow radially out of the object. Such an object would then be called a(n)

a) electric monopole b) magnetic monopole c) electric dipole

d) magnetic dipole e) electric quadrapole

9. Who was the first to realize that charge comes in only two varieties, positive and negative?

a) Newton b) Coulomb c) Volta d) Ohm e) none of these

10. If an E-field in the Earth's atmosphere exceeds the dielectric strength of the atmosphere, which of the following will occur?

a) rain storm b) fog c) lightning d) rainbow e) sunset

11. Charge exchange between two isolated objects resulting from the generated electric field is called

a) advection b) accretion c) induction

d) convection e) conduction

12. The expression $\Delta V = IR$ is known as

a) Coulomb's law b) Ampere's law c) Ohm's law

d) Kepler's law e) Gauss's law

13. Which of the following physicists formulated the force law between two charges?

a) Volta b) Galileo c) Newton d) Gauss e) Coulomb

14. What is the name of the device that transfers charge from a charged source to a large dome by means of a rotating belt?

a) Coulomb belt b) Van der Graaff generator c) galvanometer

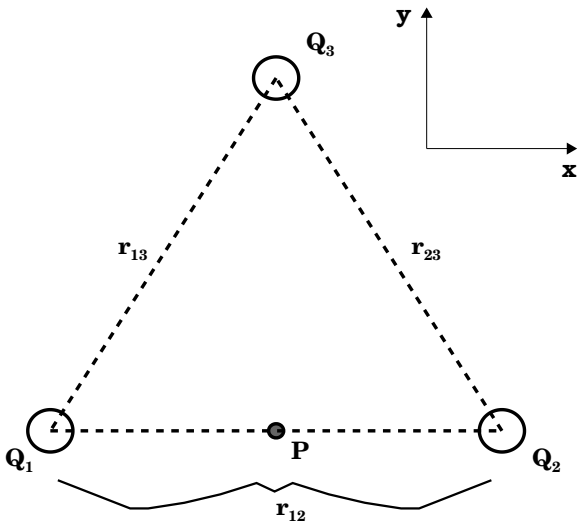
d) Ampere motor e) Millikan oil-drop belt

15. The equation $\Phi_E = Q_{\text{in}}/\epsilon_\circ$ is called whose law?

a) Newton's b) Coulomb's c) Volta's d) Ohm's e) none of these

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

16. In the figure below, let $Q_1 = +6.84\ \mu$C, $Q_2 = $-16.2 μC, and $Q_3 = +9.20\ \mu$C be rigidly fixed and separated by $r_{12} = r_{13} = r_{23} = 1.34$ m. Calculate the electric potential at point **P** which is half-way between Q_1 and Q_2. (**Show all work!**)



17. A gold wire of length 13.7 cm and diameter 0.188 mm is going to be used to construct a thermocouple. Gold has a temperature coefficient of resistivity of 3.40×10^{-3} °C^{-1}. (a) At 20.0°C, gold has a resistivity of 2.44×10^{-8} Ω·m, what is the resistance of this wire at this temperature? (b) After constructing our thermocouple, we place it into a liquid of unknown temperature and apply a voltage across the leads of the termocouple of 0.224 V. If we measure a current of 0.884 A going through this thermocouple, what is the temperature of this liquid in °C? (**Show all work!**)

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

18. Two protons are near the surface of the Earth. The first proton is placed securely on the ground. How high will the second proton have to be placed in order to just remain stationary above the Earth's surface? (*Hint:* Think about the two forces that would be involved. **Show all work!**)