Physics 227 SECOND COMMON HOUR EXAM
Thursday, October 31, 2002
Profs. Shapiro and Devlin

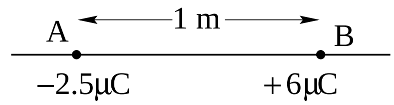
⇒ ⇐

Your name sticker with **exam code**

Turn off and put away cell phones now!

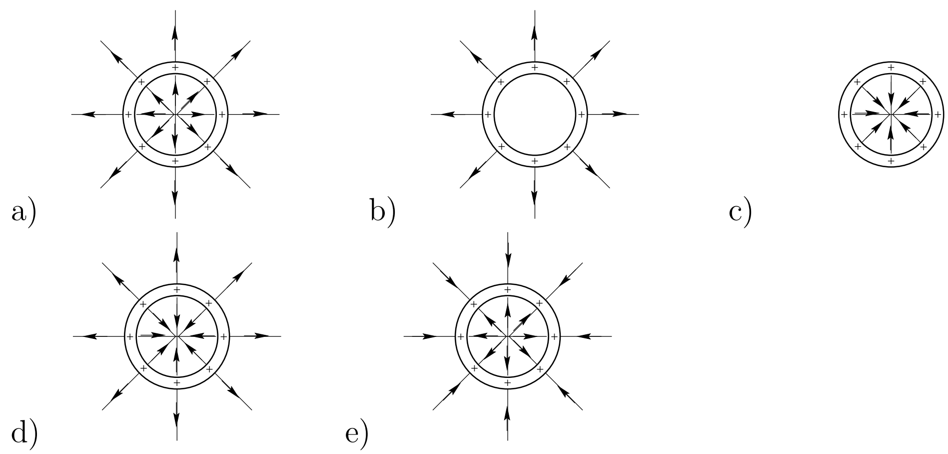
1. The exam will last from 8:00 – 9:20 p.m. Use a #2 pencil to make entries on the answer sheet. Enter the following ID information now, before the exam starts.
2. In the section labelled NAME (Last, First, M.I.) enter your last name, then fill in the empty circle for a blank, then enter your first name, another blank, and finally your middle initial.
3. Under STUDENT # enter your 9-digit Social Security Number.
4. Enter 227 under COURSE, and your section number (see label above) under SEC.
5. **Under CODE enter the exam code given above.**
6. During the exam, you may use pencils, a calculator, and one 8.5 x 11 inch sheet with formulas and notes.
7. There are 18 multiple-choice questions on the exam. For each question, mark only one answer on the answer sheet. There is no deduction of points for an incorrect answer, so even if you cannot work out the answer to a question, you should make an educated guess. **At the end of the exam, hand in the answer sheet and this cover page. Retain the rest of this exam for future reference and study.**
8. When you are asked to open the exam, make sure that your copy contains all 18 questions. Raise your hand if this is not the case, and a proctor will help you. Also raise your hand during the exam if you have a question.
9. Please SIGN the cover sheet under your name sticker and have your student ID ready to show to the proctor during the exam.

1. Two point charges are separated by 1 m as shown in the figure. The point where the total electric field is zero (other than infinity) is

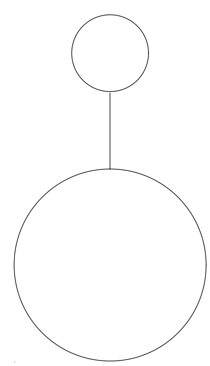


   a. nowhere other than infinity
   b. on the line AB, between A and B
   c. on the line AB, to the left of A
   d. above AB
   e. on the line AB, to the right of B

2. A very long hollow lucite tube is rubbed with cat's fur so that it acquires a net positive charge that is uniformly distributed on its surface. Looking down the end of the tube, which diagram best represents the electric field lines near the tube?

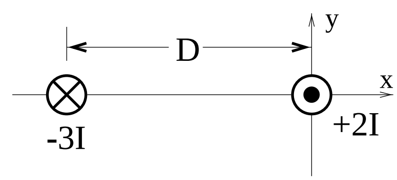


3. Two conducting, hollow spheres have different radii. A thin, conducting wire connects the spheres. A charge Q is placed on the smaller sphere. Then,



   a) There will be no flow of charge, so the charge Q will remain on the smaller sphere.
   b) all of the charge will flow to the larger sphere.
   c) charge will flow until the spheres have equal electric fields at their surfaces.
   d) charge will flow until the spheres have equal potentials.
   e) charge will flow until the spheres have equal charges.

4. At $x = 0$, a long straight wire carries current $2I$ **out** of the plane of the paper. At $x = -D$, another long straight wire carries current $3I$ **into** the plane of the paper. What is the direction of the force on the wire at $x = -D$?

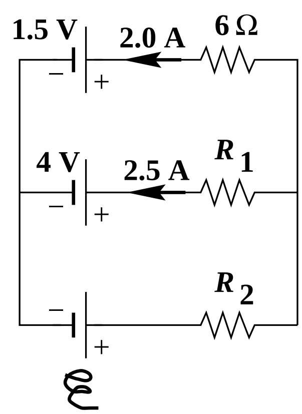


a) in the positive x-direction
b) in the positive y-direction
c) in the negative y-direction
d) none of the other answers
e) in the negative x-direction

5. Two straight wires A and B of circular cross-section are made of the same metal and have equal lengths, but the resistance of wire A is four times greater than that of wire B. How do their radii compare?

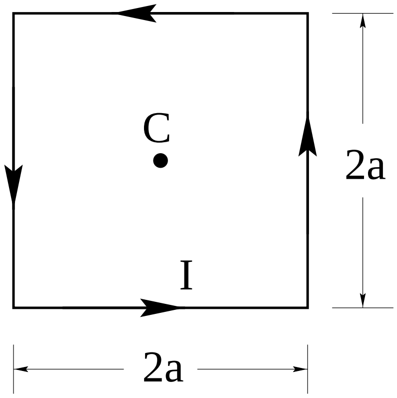
a) $r_A = r_B/16$
b) $r_A = 2r_B$
c) $r_A = r_B/4$
d) $r_A = 4r_B$
e) $r_A = r_B/2$

6. What is the resistance of R_1 in the circuit shown?



a) 2.6 Ω
b) 5.8 Ω
c) 7.0 Ω
d) None of the other answers
e) 3.8 Ω

7. A current I flows counterclockwise around a square loop with side $2a$. This creates a magnetic field which is not uniform. At the center of the square C, the magnetic field will be a vector sum of contributions from each of the four sides. The magnitude of the contribution, $\vec{B}_1(C)$, that the bottom side makes to the total $\vec{B}(C)$ is

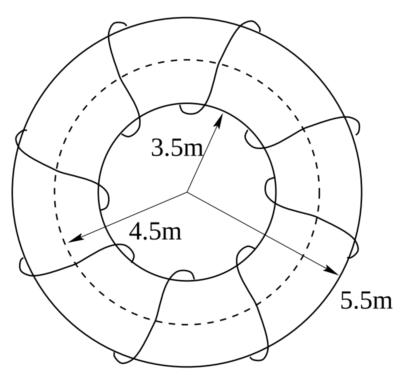


a) $\vec{B}_1(C) = \dfrac{\mu_0 I}{2\pi a}$
b) $\vec{B}_1(C) = \dfrac{\mu_0 I}{4\pi a}$
c) $\vec{B}_1(C) = \dfrac{\mu_0 I}{8a}$
d) $\vec{B}_1(C) = \dfrac{\mu_0 I}{4\pi} \int_{-a}^{a} \dfrac{a\,dx}{(a^2 + x^2)^{3/2}}$
e) $\vec{B}_1(C) = \dfrac{\mu_0 I}{4\pi} \int_{-a}^{a} \dfrac{dx}{a^2 + x^2}$

8. In the previous problem, each side makes a contribution $\vec{B}_i(C)$ to the total magnetic field $\vec{B}(C)$ at the center of the square. Each of these contributions has the same magnitude. The total field at the center, $\vec{B}(C)$ is

a) $4|B_1(C)|$, pointing downwards on the page.
b) $4|B_1(C)|$, pointing into the page.
c) zero, as opposite side's contributions cancel.
d) $4|B_1(C)|$, pointing upwards on the page.
e) $4|B_1(C)|$, pointing out of the page.

9. A Tokamak Fusion Test Reactor has a magnetic field generated by a 1600-turn toroidal coil as shown. The inner and outer radii of the toroidal coil are $a = 3.5$ m and $b = 5.5$ m, respectively. In operating, a current of 73,000 amperes is passed through the coil. What is the magnitude of the magnetic field at the midpoint of the toroid, i.e. at a radius of 4.5 m?

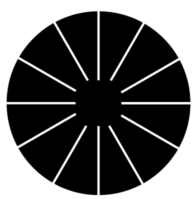


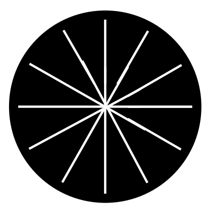
a) 10.6 T
b) 23.4 T
c) 9.0×10^{-8} T
d) 0.19 T
e) 5.2 T

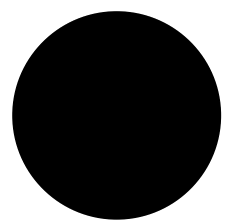
10. In a paramagnetic substance of permeability μ, the magnetic intensity $\vec{H}$ and the magnetization $\vec{M}$ can be related as follows:

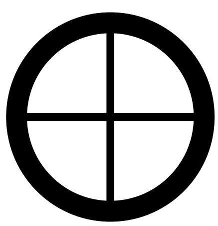
a) $\vec{H} = \mu_0 \vec{M}/(\mu - \mu_0)$
b) $\vec{H} = (\mu - \mu_0)\vec{M}$
c) $\vec{H} = \mu \vec{M}$
d) $\vec{H} = \vec{M}/(\mu - \mu_0)$
e) $\vec{H} = \vec{M}/\mu$

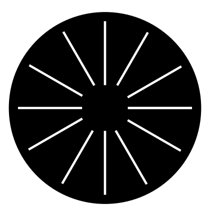
11. Five disks, some slotted, are made of copper as shown, with the black representing the copper. They are rolled down an inclined plane and pass through a region with an intense magnetic field perpendicular to the disk. The one which is slowed down the *least* in passing through the magnetic field is

a) 

b) 

c) 

d) 

e) 

12. The maximum energy that can be stored in an 0.4 mH inductor is 0.01 J. What maximum current can the inductor carry?

a) 7.1 A
b) 25.0 A
c) 3.5 A
d) 50.0 A
e) 5.0 A

13. In discussing LC circuits, an analogy was made to the motion of a mass on a spring, with the inductance related to the mass and the capacitance to the spring constant. This is because

   a) Inside an inductor the current carriers are heavy electrons.
   b) the electric field in the capacitor causes the plates to be attracted to each other and to bend, making a spring.
   c) the differential equations are the same, with the second derivative terms having coefficients of L and m, while the non-derivative terms have coefficients $(1/C)$ and k respectively.
   d) inductors are wound on heavy iron cores.
   e) The electric field inside the capacitor stretches the electrons like a spring.

14. A dipole antenna

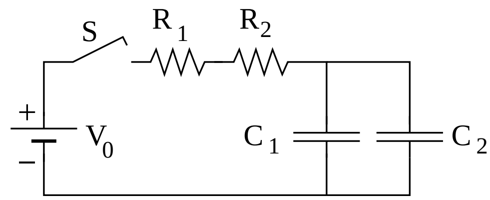
   a) radiates most strongly perpendicular to the antenna, with the electric field also perpendicular to the antenna.
   b) radiates evenly in all directions, with the electric field perpendicular to the antenna.
   c) radiates evenly in all directions with the electric field in the radial direction.
   d) radiates most strongly in the direction that the antenna points.
   e) radiates most strongly perpendicular to the antenna, with the electric field parallel to the antenna.

15. A metal spherical shell of radius 1-cm is at a potential of 100-V (with respect to $r = \infty$). What is the net charge on the sphere?

   a) 1.11×10^{-10} C
   b) 9.99-μC
   c) 1.11×10^{9} C
   d) 1.11×10^{7} C
   e) 3.33×10^{-9} C

16. What is the time constant of the circuit shown?

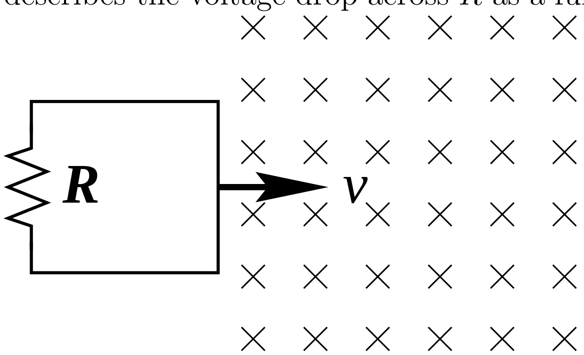
   a) $\tau = \frac{(R_1+R_2)(C_1C_2)}{(C_1+C_2)}$
   b) $\tau = \frac{R_1R_2(C_1C_2)}{(R_1+R_2)(C_1+C_2)}$
   c) $\tau = (R_1+R_2)(C_1+C_2)$
   d) $\tau = (R_1+R_2)/(C_1+C_2)$
   e) $\tau = \frac{R_1R_2(C_1C_2)}{(R_1+R_2)}$

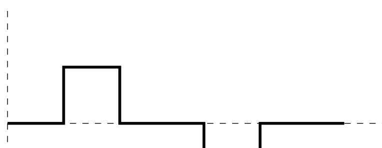


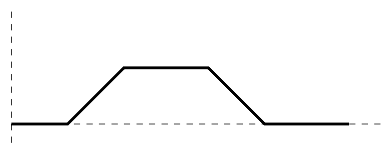
17. If the wavelength of an electromagnetic wave is 5.5×10^{-7} m, its *angular* frequency is:

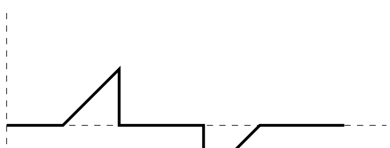
a) 3.4×10^{15} rad/sec
b) 1.1×10^{16} rad/sec
c) 6.8×10^{15} rad/sec
d) 5.4×10^{14} rad/sec
e) 1.7×10^{15} rad/sec

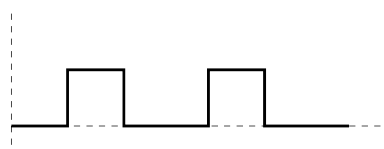
18. A rectangular loop containing a resistor R moves with constant velocity v into, through, and out of a region of constant, uniform magnetic field B perpendicular to the plane of the loop as shown. Which of the graphs best describes the voltage drop across R as a function of time for this sequence?

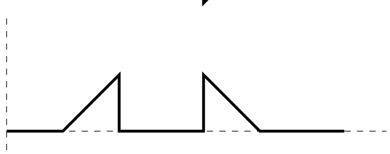


a) 

b) 

c) 

d) 

e) 

19. The DC-10 airplane has a wingspan of 47 m. The aircraft is flying horizontally at 960 km/hr at a place where the vertical component of the earth's magnetic field is 6.0×10^{-5} T, and the horizontal component is 4.0×10^{-5} T in the direction of motion of the plane. What is the induced voltage between its wingtips?

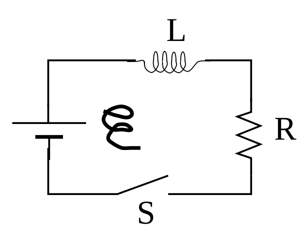
a) 0.50 V
b) 0.90 V
c) 2.7 V
d) 19 V
e) 0.75 V

20. The current in a solenoid increases steadily from 0 to 10 mA in 40 ms. If the self-induced emf is 8×10^{-4} V, what is the solenoid's inductance?

a) 8.0 mH
b) 0.8 mH
c) 0.2 mH
d) Cannot be determined from the information given
e) 3.2 mH

21. In the LR circuit below, the current builds up to one-quarter of its steady (final) value in 2 seconds after the switch is closed. What is the time constant for this circuit?

a) 7 sec
b) 2.8 sec
c) 1.4 sec
d) 0.58 sec
e) 8.0 sec



22. The resonant frequency of a certain LC circuit is 6×10^5 Hz. If the capacitance is then doubled and the inductance is tripled, what will be the new resonant frequency?

a) 6×10^5 Hz
b) 1×10^5 Hz
c) 3.60×10^5 Hz
d) 2.45×10^5 Hz
e) 1.47×10^5 Hz

23. A 300 mH inductor is connected across an AC voltage source of $(170\text{V})\sin(377t)$. What is the maximum current flowing through the inductor?

a) 567 A
b) 0.13 A
c) 0.67 A
d) 19.2 kA
e) 1.5 A

24. A capacitor is connected to an ac source whose peak voltage is 12 V and whose angular frequency in 4000 rad/s. If the maximum current is 0.1 A, what is the capacitance?

a) 2.1×10^{-4} F
b) 0.03 F
c) 8.3×10^{-3} F
d) 2.1×10^{-6} F
e) 3×10^{-4} F

25. In a certain series RLC circuit driven by an applied voltage of $(170\text{V})\sin(377t)$, the current through the circuit is
$(0.8\text{A})\sin(377t - 0.5)$. (Here t is measured in seconds and the argument of the sin is in radians.) The average power supplied by the voltage source is

a) 60 W
b) 68 W
c) 136 W
d) 119 W
e) 32.6 W

26. The magnetic field in a plane EM wave is given by

$$\vec{B} = B_m \cos(kx - \omega t)\hat{y}.$$

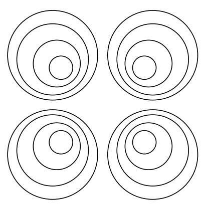
The associated electric field is

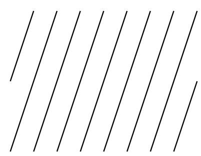
a) $cB_m \cos(kx - \omega t)(-\hat{z})$
b) $(B_m/c)\cos(kx - \omega t)(\hat{y})$
c) $cB_m \cos(kz - \omega t)(\hat{x})$
d) $(B_m/c)\sin(ky - \omega t)(\hat{x})$
e) $cB_m \sin(kx - \omega t)(\hat{z})$

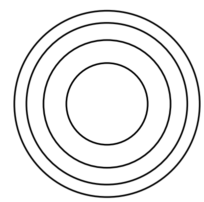
27. The Sun delivers about 1000 $\mathrm{W/m^2}$ of electromagnetic flux to the Earth's surface. What is the maximum value of the electric field at the surface, due to the sunlight?

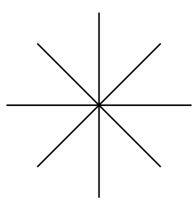
a) 868 V/m
b) 1.5×10^7 V/m
c) 7.5×10^5 V/m
d) 31.6 V/m
e) 614 V/m

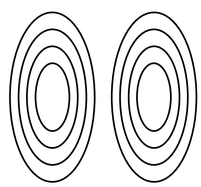
28. A finite region of a much larger field is illustrated in each of the diagrams. Which cannot represent a magnetic field?

a) 

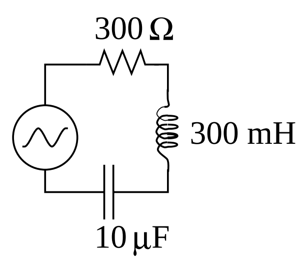
b) 

c) 

d) 

e) 

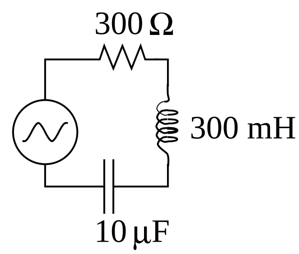
29. A series RLC circuit with $R = 300\Omega$, $L = 300$ mH, $C = 10\mu$F, is driven by an applied voltage of (170V) sin(377t), where t is in seconds. The maximum current through the circuit is



a) 0.944 A
b) 0.566 A
c) 0.352 A
d) 0.505 A
e) 0.407 A

30. A series RLC circuit with $R = 300\Omega$, $L = 300$ mH, $C = 10\mu$F, is driven by an applied voltage of (170V) sin(377t), where t is in seconds. In this circuit

a) the current leads the applied voltage by 44°.
b) the current leads the applied voltage by 27°.
c) the current and the applied voltage are in phase.
d) the current lags behind the applied voltage by 44°.
e) the current lags behind the applied voltage by 27°.

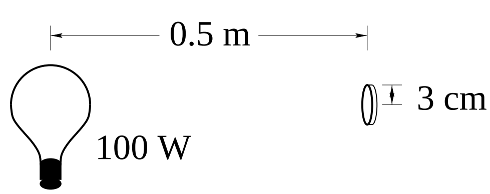


31. To drive many electronic devices which require 5 V DC, the 110 V (rms) AC supplied by your wall socket is first converted to an AC EMF with an amplitude (maximum voltage) of 9 V. Suppose this is done with an ideal transformer with a primary winding of 1000 turns connected to the plug which goes into your wall socket. How many turns are needed in the secondary winding?

a) 1000 turns
b) 12,200 turns
c) 82 turns
d) 58 turns
e) 116 turns

32. A circular mirror of radius 3 cm is 0.5 m away from a 100 W light bulb, which emits its energy equally in all directions. The mirror reflects all the light incident upon it, directly back at the bulb. What is the total force on the mirror due to the light bulb?

a. 9.0×10^{-2} N
b. 0.18 N
c. 2.1×10^{-7} N
d. 1.5×10^{-10} N
e. 6.0×10^{-10} N

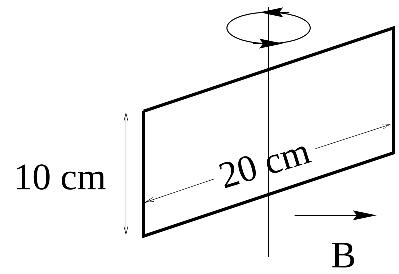


33. Two long solenoids with radii of 20 mm and 30 mm, respectively, carry the same amount of current. The smaller solenoid is mounted inside the larger, along a common axis. It is observed that there is zero magnetic field within the inner solenoid. Therefore the inner solenoid must have X times as many turns per unit length as the outer solenoid, where X is:

a) $\frac{3}{2}$ b) $\frac{2}{3}$ c) $\frac{4}{9}$ d) $\frac{9}{4}$ e) 1

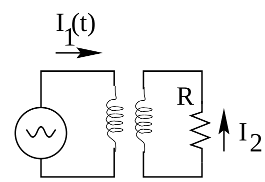
34. An electric generator consists of a rectangular coil of wire rotating about an axis which is perpendicular to a magnetic field of 2.0×10^{-2} T. The coil measures 10.0 cm $\times$ 20.0 cm and has 120 turns of wire. At what rate (in revolutions per second) must you rotate this coil in order to induce an alternating EMF of peak amplitude 12.0 V between the ends of the coil?

a) 4770 rev/sec
b) 250 rev/sec
c) 40 rev/sec
d) 0.80 rev/sec
e) 5.0 rev/sec



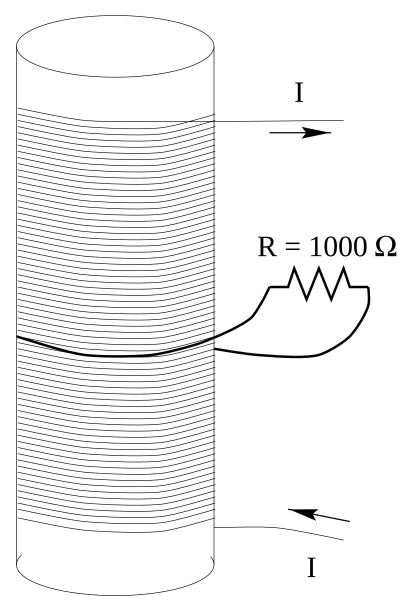
35. Two coils are close to each other, with one connected to an alternating current source which produces a current of $I_1(t) = (5.0\text{A})\sin(377t)$, while the other is connected to a resistor of 12Ω. If the current I_2 has a maximum of 0.40 A, what is the mutual inductance of the two coils?

a) 212 μH
b) 80 mH
c) 2.55 mH
d) 0.96 mH
e) 12.5 H



36. A long solenoid coil of radius 2 cm and length 75 cm is wound with wire with 3,000 turns per meter. Another wire makes one turn about the midpoint of the solenoid, and is connected to a resistor of 1000 Ω. If the solenoid coil has a current which increases linearly from zero to .2 A in 0.3 seconds, the current through the resistor, R, is

a) 0.95 nA, to the right
b) 3.16 nA, to the right
c) 3.16 nA, to the left
d) 0.95 nA, to the left
e) zero



Some possibly useful information:
c = speed of light = 3.00×10^8 m/s
$q_e = -e$ = charge on an electron = -1.602×10^{-19} Coulombs
$q_p = +e$ = charge on a proton = $+1.602 \times 10^{-19}$ Coulombs
m_e = electron mass = 9.11×10^{-31} kg
m_p = proton mass = 1.67×10^{-27} kg
$k_e = 8.99 \times 10^9\ \mathrm{N \cdot m^2/C^2}$
$\epsilon_0 = 8.85 \times 10^{-12}\ \mathrm{C^2/N \cdot m^2}$
$\mu_0 = 4\pi \times 10^{-7}\ \mathrm{T \cdot m/A}$
$g = 9.80\,\mathrm{m/s^2}$
N_A = Avogadro's number = 6.022×10^{23} particles/mol
1 mHz = 10^{-3} Hz   1 kHz = 10^{+3} Hz   1 MHz = 10^{+6} Hz   1 GHz = 10^{+9} Hz
1 mC = 10^{-3} C   1 μC = 10^{-6} C   1 nC = 10^{-9} C   1 pC = 10^{-12} C