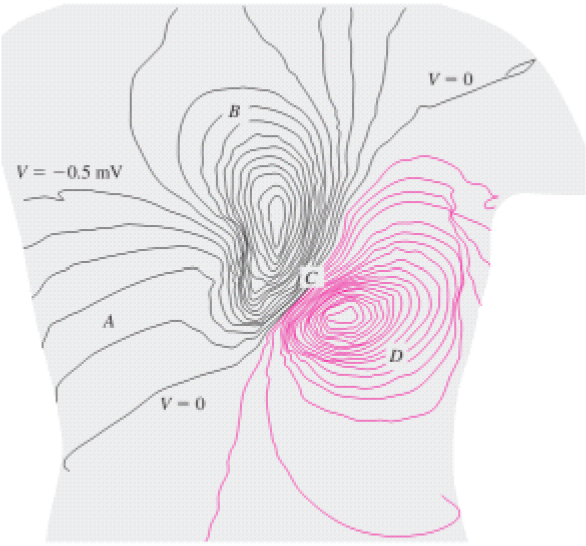
Section Eight Electrical potential

Part one

Standard electrocardiography measures time-dependent potential differences between multiple points on the body, giving cardiologists multiple perspectives on the heart's electrical activity. In contrast, Fig. 8.1 is a "snapshot" showing a more detailed picture at an instant of time. The lines are equipotentials on the surface of a human torso, associated with the heart's electrical activity. Relative to the line marked the potential is negative to the upper left (black) and positive to the lower right (green).



1. From the e2quipotentials, you can infer that the heart's electrical structure resembles that of a

a. uniform charged sheet.

b. dipole.

c. point charge.

d. uniformly charged sphere.

2. The electric field in the vicinity of the heart points approximately

a. from upper left to lower right.

b. from lower left to upper right.

c. from upper right to lower left.

d. from lower right to upper left.

3. The electric field is strongest in the region marked

a. A.

b. B.

c. C.

d. D.

4. The electric field in region A is approximately

a. 20

b. 2 mN/C.

c. 20 mN/C.

d. 2 kN/C.

Nuclear fusion could provide humankind with limitless energy, making a gallon of seawater the energy equivalent of 300 gallons of gasoline. The National Ignition Facility (NIF) at Lawrence Livermore National Laboratory was designed for the “ignition” of nuclear fusion by bombarding a tiny deuterium-tritium pellet with energy from 192 converging laser beams. The NIF lasers deliver 2 MJ of energy in about 1 ns; Fig. 8.2 shows the target chamber where the laser beams converge. The energy is stored in capacitors that, because of conversion inefficiencies, have to store some 400 MJ. (Note:NIF is more complicated than described here, and the numbers and technical descriptions are only approximate.)

5. What total capacitance is required if the capacitor system is charged to 20 kV?

a. 100 μF

b. 200 μF

c. 1 F

d. 2 F

6. If it were technically and economically feasible to double the voltage, how would the required capacitance change?

a. drop to 1/4 its original value

b. drop to 1/2 its original value

c. would not change

d. would double

77. While they’re firing, the power delivered by the laser beams is

a. 2 MW

b. 2 GW

c. 2 TW

d. 2 PW

78. Among the capacitors that store energy at NIF are 1200
units charged to about 20 kV. The energy stored in each capaci-tor is about

a. 3 J.

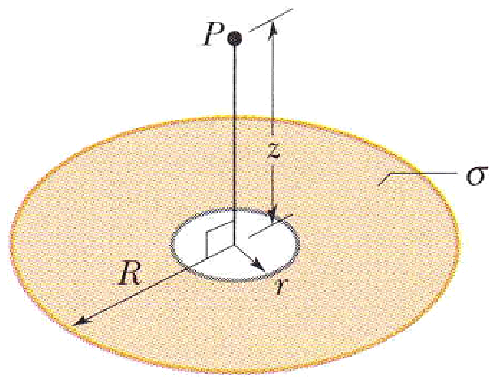
b. 20 kJ.

c. 60 kJ.

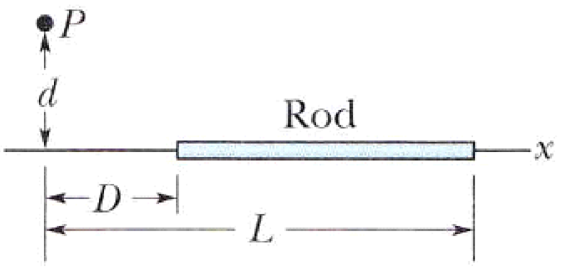
d. 400 MJ

Part Two

1 Figure 8.3 shows a ring of outer radius R =13.0 cm, inner radius r = 0.200R, and uniform surface charge density σ=6.20pC/m^2.With V = 0 at infinity, find the electric potential at point P on the central axis of the ring, at distance z =2.00R from the center of the ring.

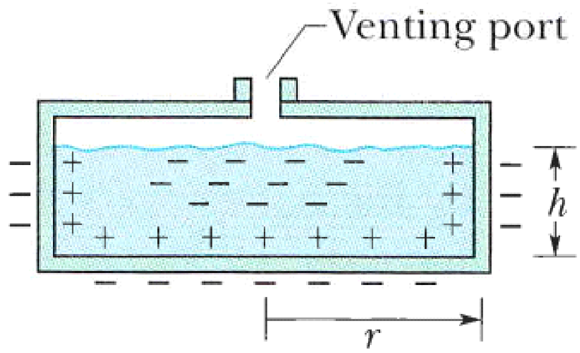


2 Figure 8.4 shows a thin rod with a uniform charge density of 2.00μC/m. Evaluate the electric potential at point P if d =D= L/4



3 As a safety engineer, you must evaluate the practice of storing flammable conducting liquids

in non-conducting containers. The company supplying a certain liquid has been using a squat, cylindrical plastic container of radius r=0.20 m and filling it to height h=10 cm, which is not the container's full interior height (Fig. 8.5). Your investigation reveals that during handling at the company, the exterior surface of the container commonly acquires a negative charge density of magnitude 2.0 μC/m^2 (approximately uniform). Because the liquid is a conducting material, the charge on the container induces charge separation within the liquid. (a) How much negative charge is induced in the center of the liquid's bulk? (b) Assume the capacitance of the central portion of the liquid relative to ground is 35 pF. What is the potential energy associated with the negative charge in that effective capacitor? (c.) If a spark occurs between the ground and the central portion of the liquid (through the venting port). the potential energy can be fed into the spark. The minimum spark energy needed to ignite the liquid is 10 mJ. In this situation, can a spark ignite the liquid?



4 The first accurate estimate of cell membrane thickness used a capacitive technique, which determined the capacitance per unit area of cell membrane in a macroscopic suspension of cells; the result was about Assuming a dielectric constant of about 3 for the membrane, find the membrane's thickness. (Note: Your answer is the thickness of the bipolar lipid layer alone, and is lower by a factor of about 3 than values based on X-ray techniques.)