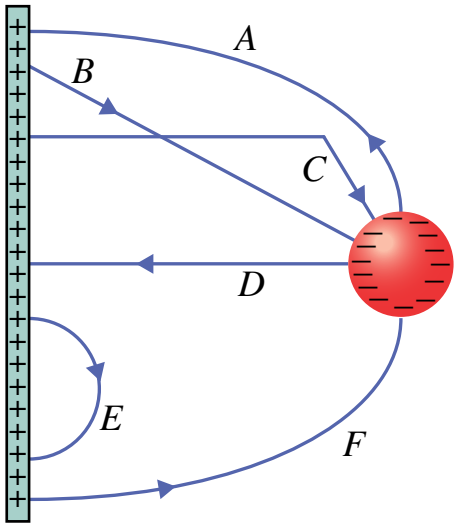
Unit 20 *Homework Problems*

Learning Goals:

F.20 Define electric flux at a surface and qualitatively compare fluxes in various scenarios.
A.20 Justify the use of Gauss's law conceptually and quantitatively apply it to a distribution of charges to solve for the electric field as a function of position.

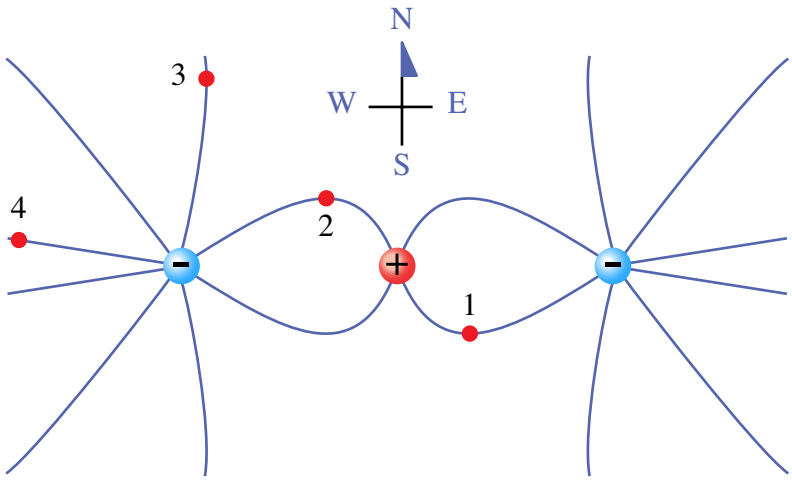
20-1) The diagram to the right shows the region in the neighborhood of a negatively charged conducting sphere and a large positively charged conducting plate extending far beyond the region shown. Someone claims that lines *A*-*F* are possible electric field lines describing the electric field lying in the region between the two conductors.



(a) Examine each of the lines and indicate whether it is a correctly drawn electric field line. If a line is not correct, explain why.

(b) Redraw the diagram with a pattern of electric field lines which are more nearly correct.

20-2) The figure below shows the electric field lines for three point charges, which are positive and negative as indicated.



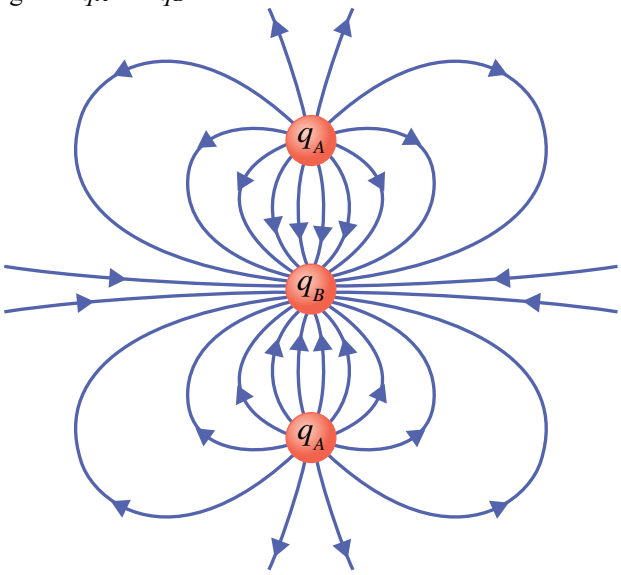
(a) Use the compass directions to indicate the *direction* of the force that a positive test charge would experience from the electric field vector at points 1, 2, 3, and 4 on the diagram.

(b) If the central charge is + 1.0 μC what are the values of the outer charges?

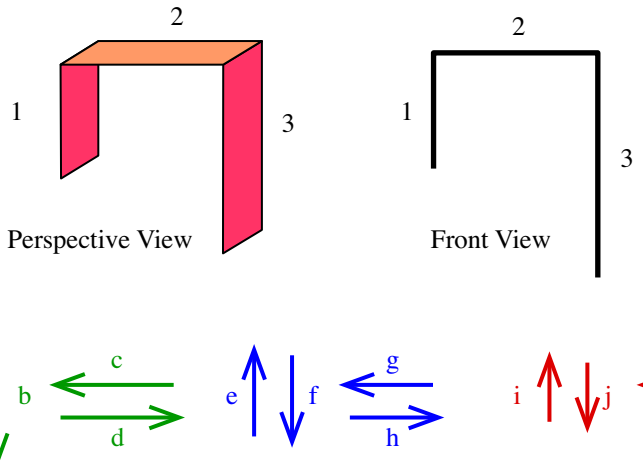
20-3) The figure at the top of the next page shows the electric field lines for three point charges separated by a small distance. The two outer charges are identical and the one in the center is different.

(a) Determine the ratio, q_A/q_B, of one of the outer charges to the inner one.

(b) Determine the signs of q_A and q_B.



20-4) A long strip of cardboard of constant width is folded as shown in the figure below into side 1 that has a short length, side 2 with a medium length and side 3 with a long length.



(a) Identify which vector of the 12 vectors shown above best represents the normal vector for side 1 of the folded cardboard.

(b) Identify which vector of the 12 vectors shown above best represents the normal vector for side 2 of the folded cardboard.

(c) Identify which vector of the 12 vectors shown above best represents the normal vector for side 3 of the folded cardboard.

20-5) Consider a uniform electric field pointing directly up with a magnitude of 350 N/C. What is the value of the electric flux at the surface of a flat rectangle of dimensions 4.0 cm by 2.0 cm when the flat surface:

(a) is vertical with its area vector point to the right

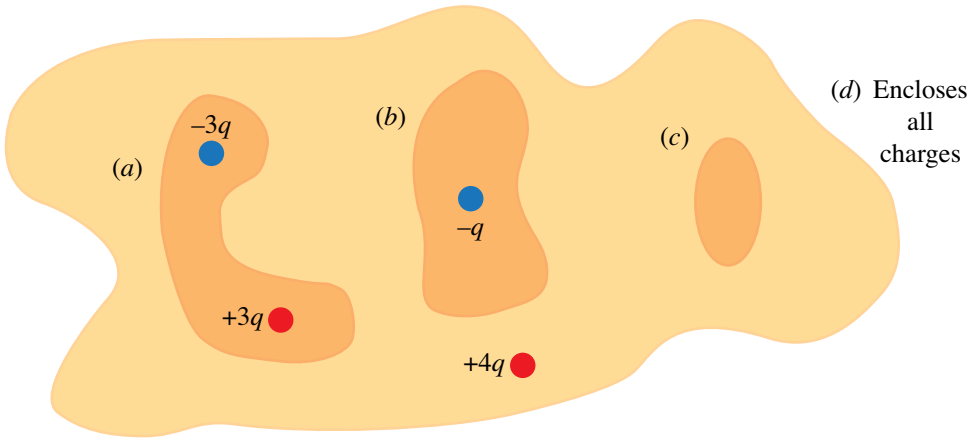
(b) is horizontal with its area vector pointing straight up

(c) is tilted so its area vector makes an angle of 45^{o} with respect to the electric field vector.

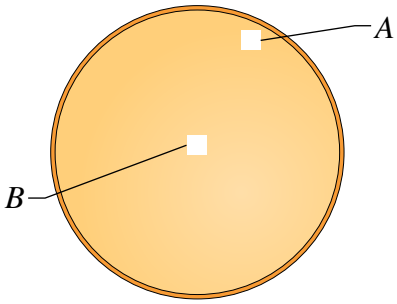
20-6) If the electric field in a region of space is zero, can you conclude there are no electric charges in that region? Explain.

20-7) If there are fewer electric field lines pointing outward at a Gaussian surface than there are pointing inward at the surface, what can you conclude about the net charge enclosed by that surface?

20-8) What is the net electric flux associated with each of the closed surfaces in the diagram below if the value of q is $+1.6\times10^{-19}$ C?



20-9) Suppose a small spherical object with excess charge is located at the center of a hollow sphere.

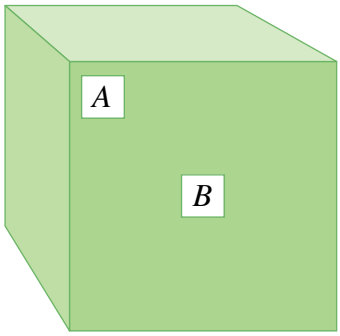


(a) Are the intersections of the field lines with the surface of the sphere uniformly distributed throughout? In other words, is the density of lines at the surface of the sphere uniform? Explain why or why not!

(b) Consider surface elements A and B, which have exactly the same area. Is the number of field lines "passing through" surface element A greater than, fewer than, or equal to the number of field lines "passing through" surface element B? Explain!

(c) Is the flux at surface element A greater than, less than, or equal to the flux at surface element B? Explain!

20-10) Suppose a small spherical object with excess charge is located at the center of a hollow cube.



(a) Are the intersections of the field lines with a side of the cube uniformly distributed across the side? In other words, is the density of lines at the surface of the box uniform? Explain why or why not!

(b) Consider surface elements A and B, which have exactly the same area. Is the number of field lines "passing through" surface element A greater than, fewer than, or equal to the number of field lines "passing through" surface element B? Explain!

(c) Is the flux at surface element A greater than, less than, or equal to the flux at surface element B? Explain!

20-11) During fair weather, an electric field of about 100 N/C points vertically downward into the earth's atmosphere. Assuming that this field arises from charge distributed in a spherically symmetric manner over the surface of the earth, determine the *net* charge of the earth and its atmosphere if the radius of the earth and its atmosphere is 6.37×10^6 m. (***Hint***: You may find it useful to look over an example in a textbook in the physics classroom – example 16-11 on page 458 of the *Physics* textbook by Giancoli (6th edition), or Section 24-6 on page 700 of the *Understanding Physics* textbook by Cummings (1st edition))