

6

For parts (a) and (b) of this problem the following formula may be helpful:

The electric field, \vec{E} , of an electric dipole, \vec{p} , at a distance \vec{r} from the dipole is:

$$\vec{E} = \frac{3\vec{r}(\vec{r} \cdot \vec{p}) - \vec{p}|\vec{r}|^2}{|\vec{r}|^5}$$

- (a) Consider an electrical dipole with equal and opposite charges separated by a distance l . The dipole is situated at a distance h above the surface of a metal half plane as shown in the figure. The dipole is in a vacuum. The axis of the dipole is oriented at an angle of θ to the normal of the surface. The metal extends to infinity on both sides and below the surface. The length of the dipole is small compared to h .

Calculate the potential energy of the dipole at the distance h above the surface of the metal (Figure 1).

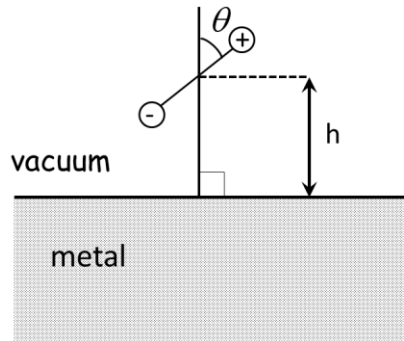


Figure 1

- (b) Calculate the potential energy between two dipoles, both in a vacuum (no metal present), separated by $2h$ and oriented as shown in Figure 2. Give the ratio of the energies in part (a) and part (b). The lengths of the dipoles are small compared to $2h$.

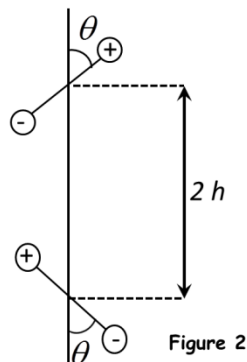


Figure 2

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6 *continued*

(c) A positive charge is situated above a semi-infinite metal slab as shown in Figure 3. Copy Figure 3 into your exam booklet.

- (1) On the figure in your exam booklet, draw the approximate shape of the electric field from the charge to the point indicated by the dot on the metal surface of the metal.
- (2) In the drawing in your exam booklet, carefully draw the electric field vectors on both sides of the metal surface at the dot, consistent with the boundary conditions. State the reasoning for your answer explicitly in terms of the boundary conditions.

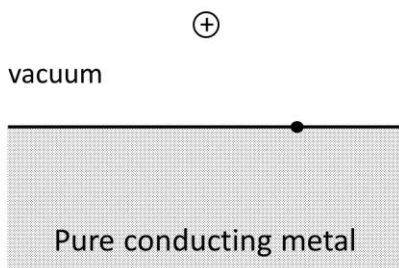


Figure 3

(d) A positive charge is situated above a semi-infinite dielectric slab as shown in Figure 4. Copy Figure 4 into your exam booklet.

- (1) On the figure in your exam booklet, draw the approximate shape of the electric field from the charge to the point indicated by the dot on the surface of the dielectric.
- (2) In the drawing in your exam booklet, carefully draw the electric field vectors on both sides of the dielectric surface at the dot, consistent with the boundary conditions. State the reasoning for your answer explicitly in terms of the boundary conditions.

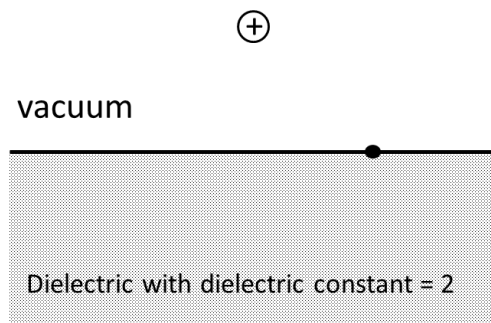


Figure 4