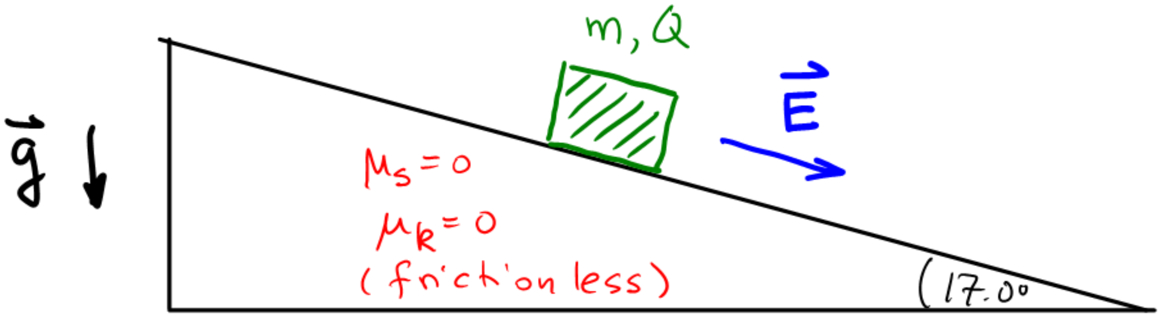
PhysicsTutor

Electric field and weight

Giambattista 16.90

Problem:

- A small charged block with mass *m*=2.35 g and charge *Q* is placed on an insulated frictionless plane inclined 17.0° with respect to the horizontal. The block does not slide down due to a 465-N/C uniform electric field pointing downward parallel to the surface. What is *Q*?



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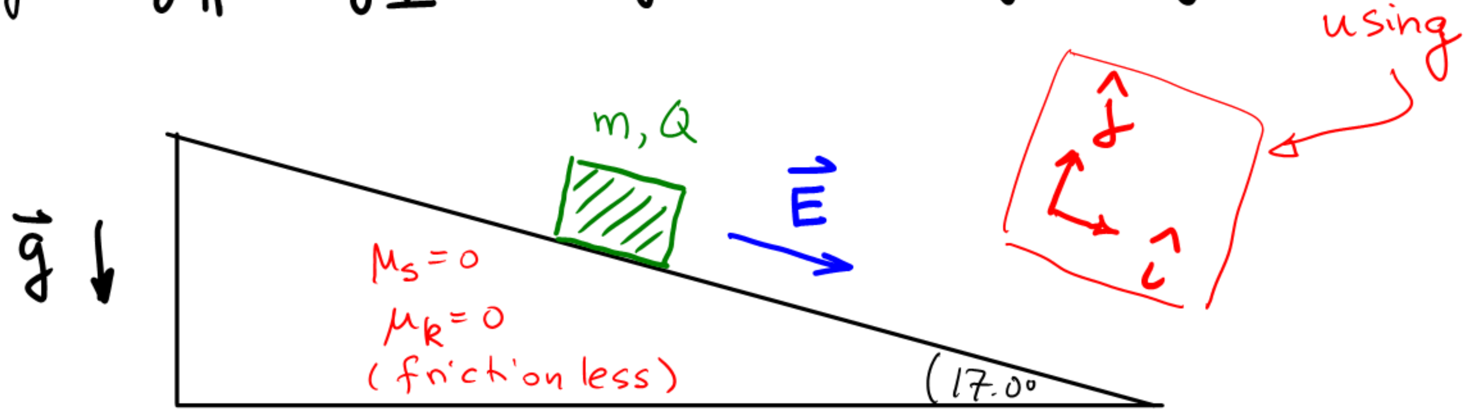
- Gravitational force component along the plane is compensated by the electric force.

$$\vec{g} = \vec{g}_{\parallel} + \vec{g}_{\perp} = g\sin\vartheta\,\hat{i} - g\cos\vartheta\,\hat{j}$$



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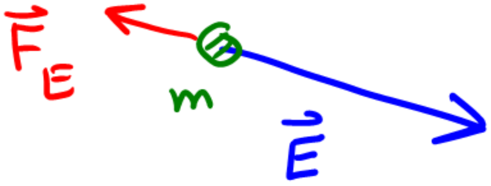
- Gravitational force component along the plane is compensated by the electric force.
- Electric field points in the same direction as gravity. Thus, the block is negatively charged.

$Q<0$: $\vec{F}_E = Q\vec{E}$



if $Q<0$
it reverses the
direction

Relevant ideas:

- Gravitational force component along the plane is compensated by the electric force.
- Electric field points in the same direction as gravity. Thus, the block is negatively charged.
- The block doesn't accelerate. The net force must be zero. As the weight component along the surface can be calculated from the given data, the charge magnitude can be deduced.

→ free-body diagram!

Equations associated with ideas:

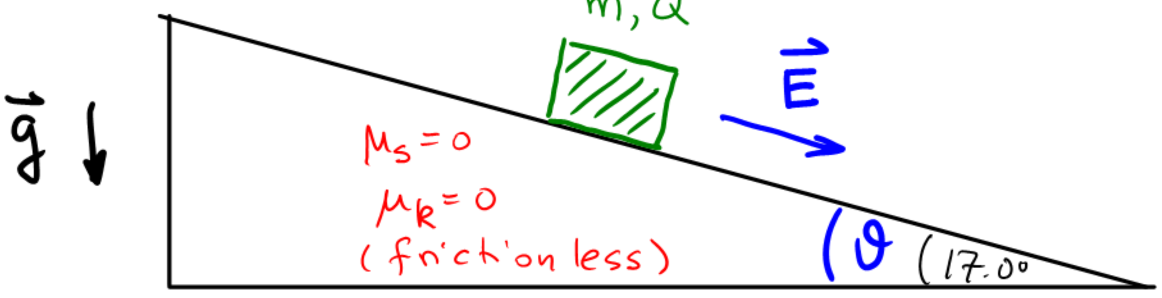
$\vec{F}_{\vec{E}} = q\vec{E}$, $m\vec{a}_{\parallel} = \vec{F}_{net} = m\vec{g}_{\parallel} + \vec{F}_{E}$

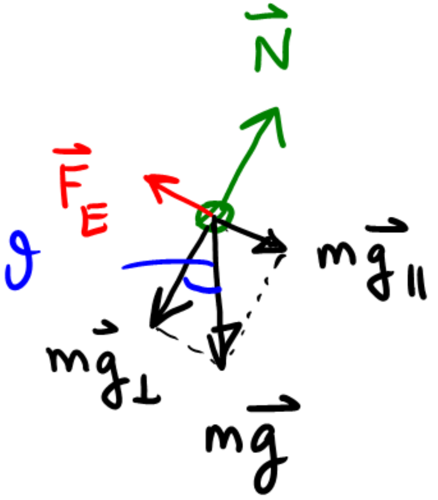
$g_{\parallel} = g\sin\vartheta$ $(\to 0 \text{ for } \vartheta \to 0)$

$g_{\perp} = g\cos\vartheta$ $(\to g \text{ for } \vartheta = 0)$

derive using geometry + trig ?

$$a_{net,\parallel} = 0 \qquad a_{net,\perp} = 0 \quad \therefore \quad \left\{ \begin{array}{l} |\vec{F}_E| = |m g_{\parallel}| \\ |\vec{N}| = |m g_{\perp}| \end{array} \right\}$$





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- Find $|Q|$ from the equilibrium condition.
- Give the answer with sign, i.e., Q= - $|Q|$.

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- We could have worked directly with $\vec{F}_E = Q\vec{E}$, used the force components along $\vec{g}_{\parallel}$, and avoided the "magnitude detour":

scalar with sign

$\hat{=}$

1 d vector

along $\vec{g}_{\parallel}$: $\quad F_E = QE = \underset{\substack{\uparrow \\ \text{opposite direction}}}{-}\,mg_{\parallel} \quad \therefore \quad Q = -\dfrac{mg\sin\vartheta}{E}$