Kinestetic activities

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Why do we need them?

Cognition is inherently embodied

Allow us to rethink stuff

Makes everything fun

Create episodic memories

Unilize analogical reasoning

When can we engage our students in kinesthetic activities?

Kinesthetic activities: Enacting

Physical Quantities	Physical processes	Physics devices and measuring instruments	Microscopic models	Graphical and Mathematical representations

Physical quantities

How big is 1 meter? Students show with their hands.

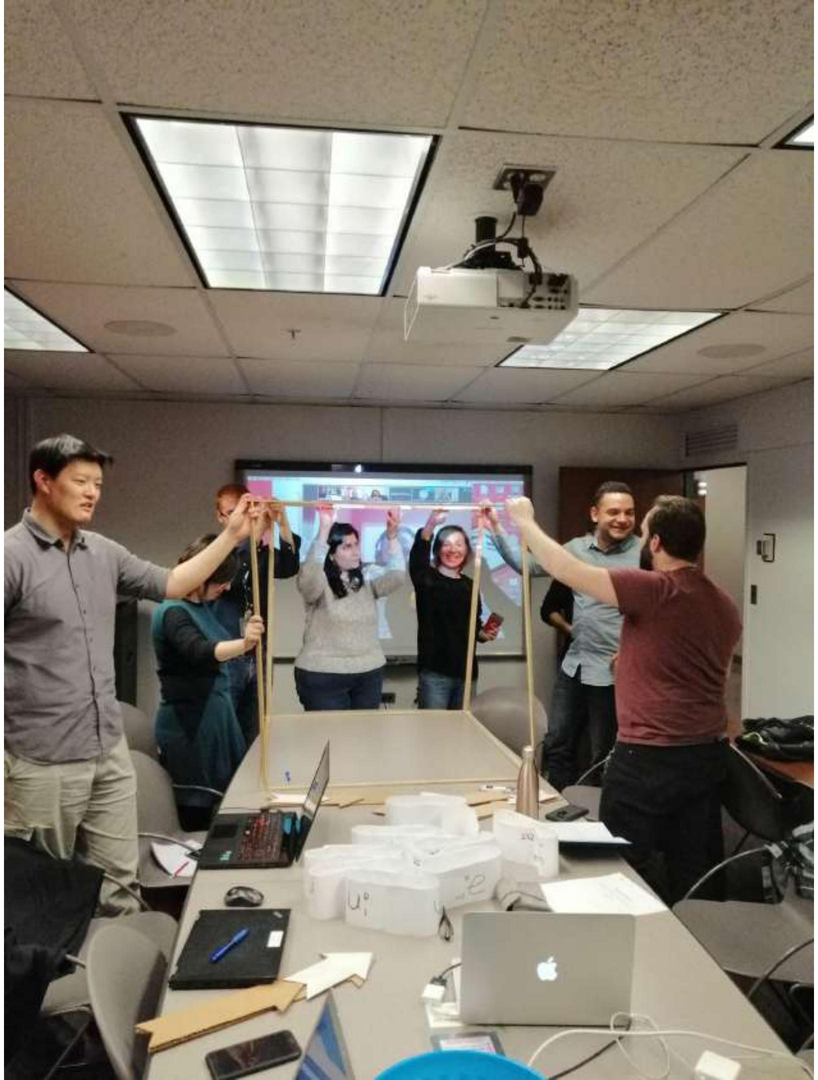
How fast is 1 m/s? 2m/s? A student follows directions from peers.

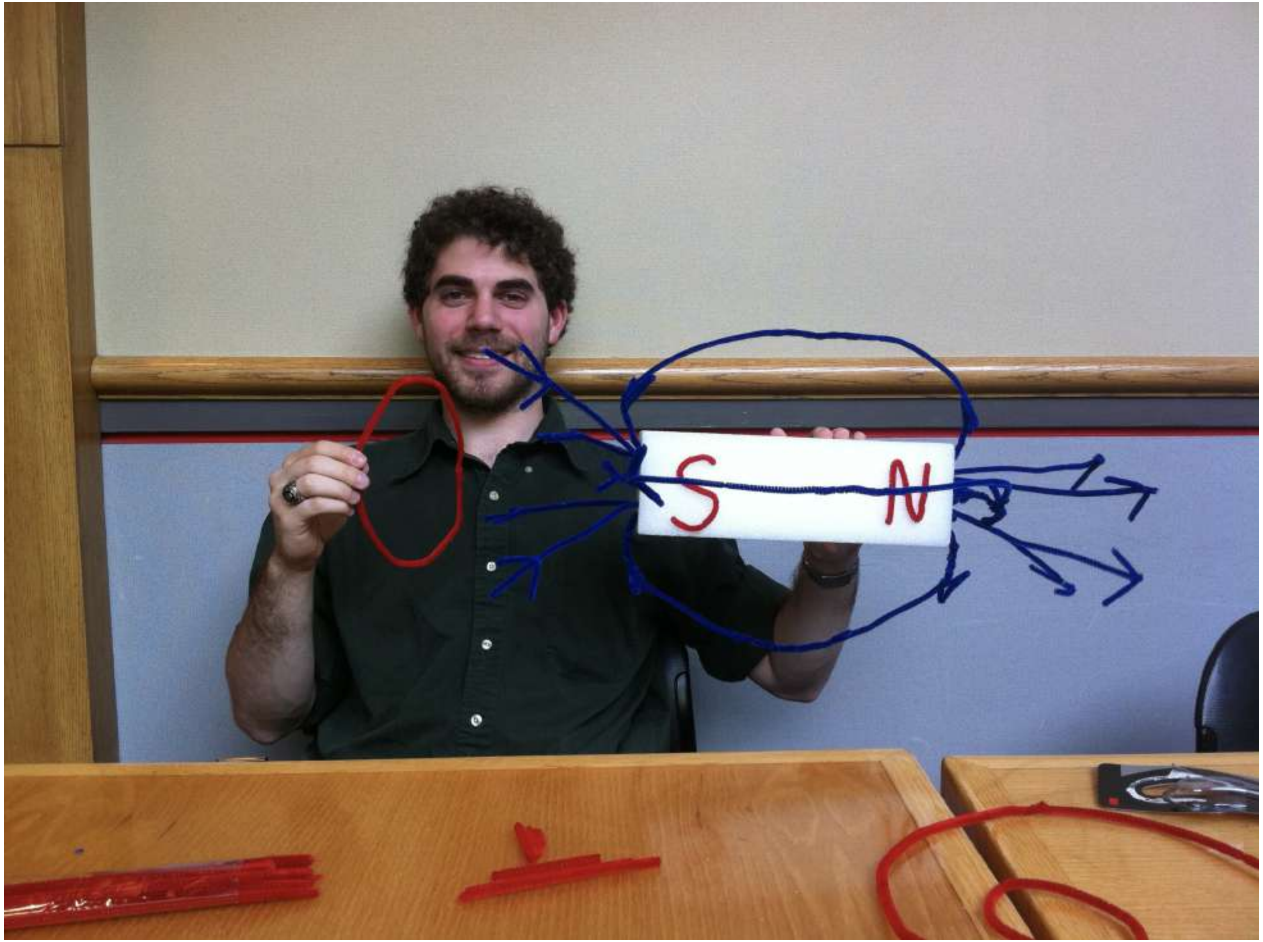
What does it mean 1m/s/s? A student follows directions from peers.

Feel 1 kg (they hold 1 l water bottles).

How to build 1 m cubed?

How to represent magnetic flux?

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Physical processes

Pushing a bowling ball exerting a constant force (impossible to film, you have to experience it yourself)

https://mediaplayer.pearsoncmg.com/assets/_frames.true/secs-experiment-video-2

Circular motion

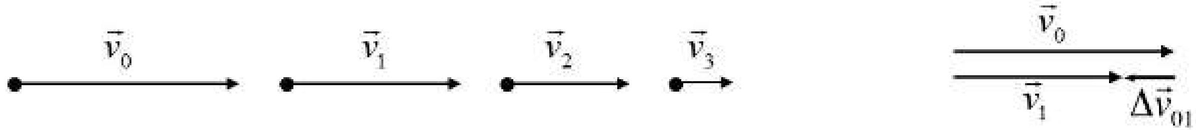
https://mediaplayer.pearsoncmg.com/assets/_frames.true/secs-egv2e-forces-exerted-on-an-object-moving-in-a-circle-at-constant-speed

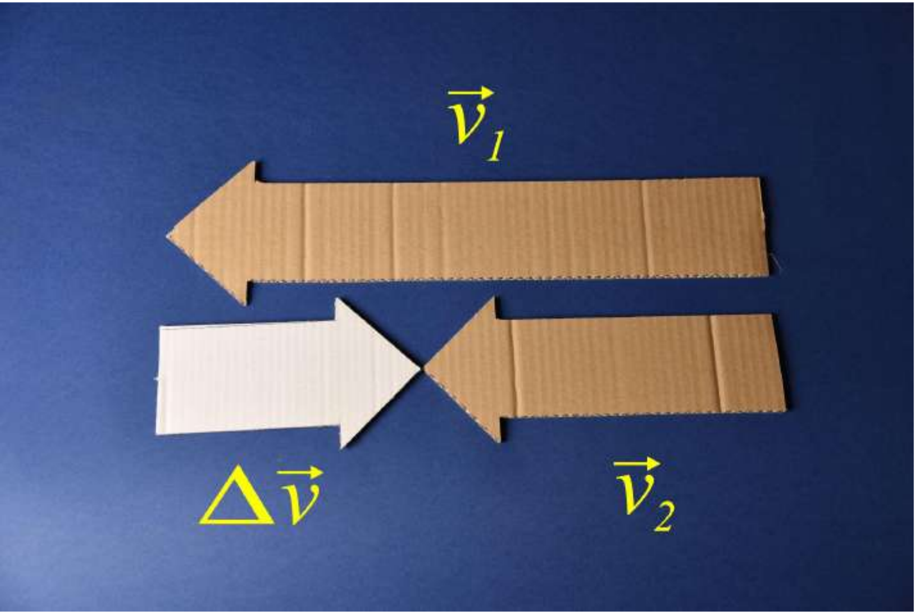
Getting off the chair (all do)

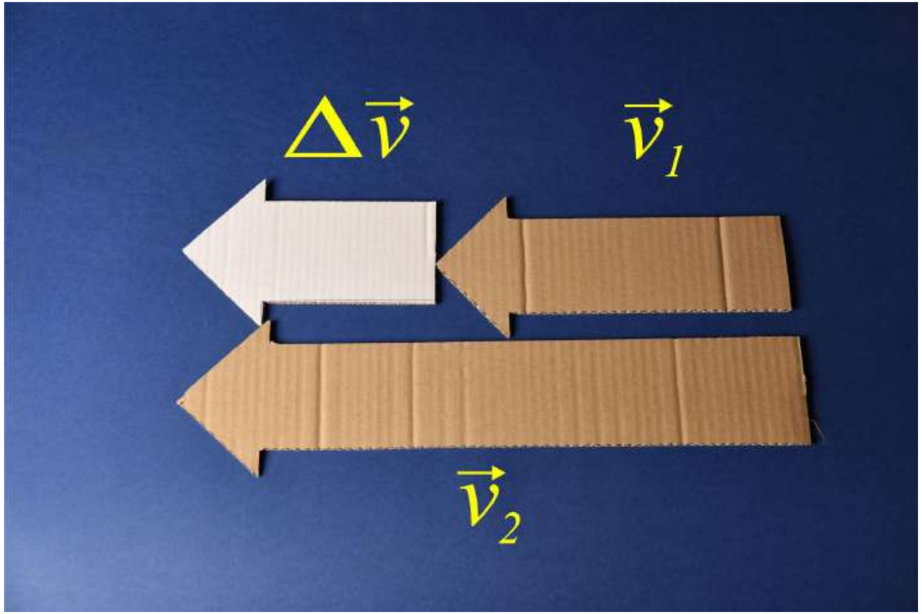
Graphical representations

OALG 2.2.5 Represent and reason

The illustration below relates to the experiment you performed with the ball in Activity 2.2.3. The dots represent the locations of the ball measured each second. The arrows represent the direction of motion and how fast the ball was moving (we call them *velocity arrows*). Consider velocity arrows 0 and 1. Move them side by side with their tails at the same horizontal position. Decide what change arrow you would have to add to arrow 0 to make it the same length as arrow 1. Repeat for arrow 1—what change arrow is needed to change it into arrow 2, and what change arrow is needed to change arrow 2 into arrow 3? We call these *velocity change arrows.*




$\vec{v}_1$
$\Delta\vec{v}$
$\vec{v}_2$


$\Delta\vec{v}$
$\vec{v}_1$
$\vec{v}_2$

Physics devices and measuring instruments

Charging and discharging an electroscope

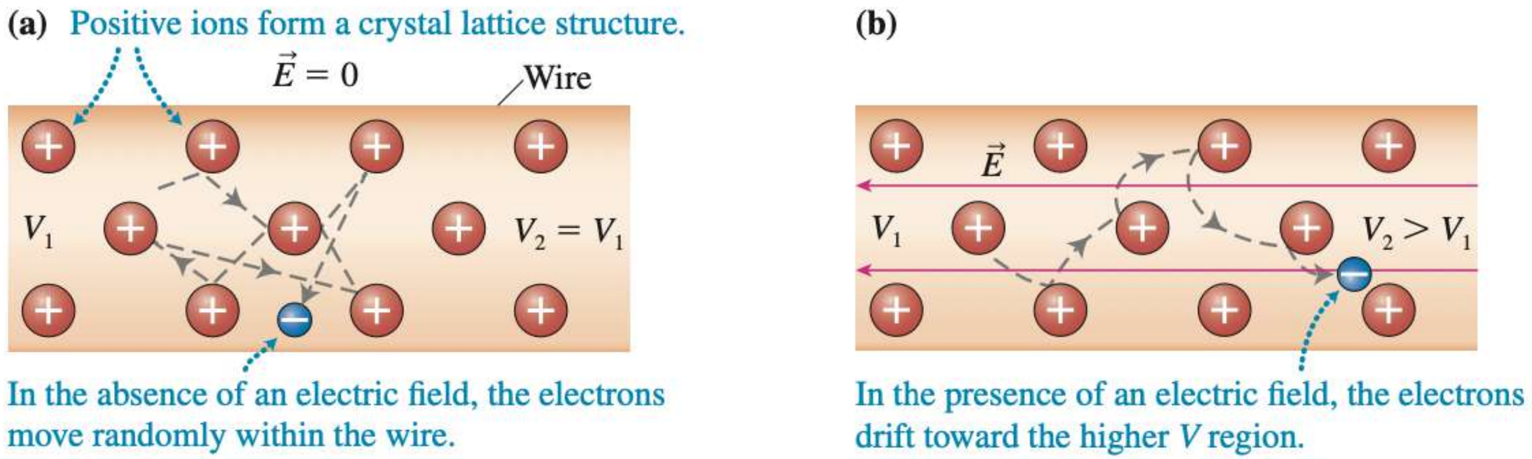
How an electroscope works (students of G. Planinsic)

https://youtu.be/YsL7pUK-_KY

Crowns and arrows and microscopic models

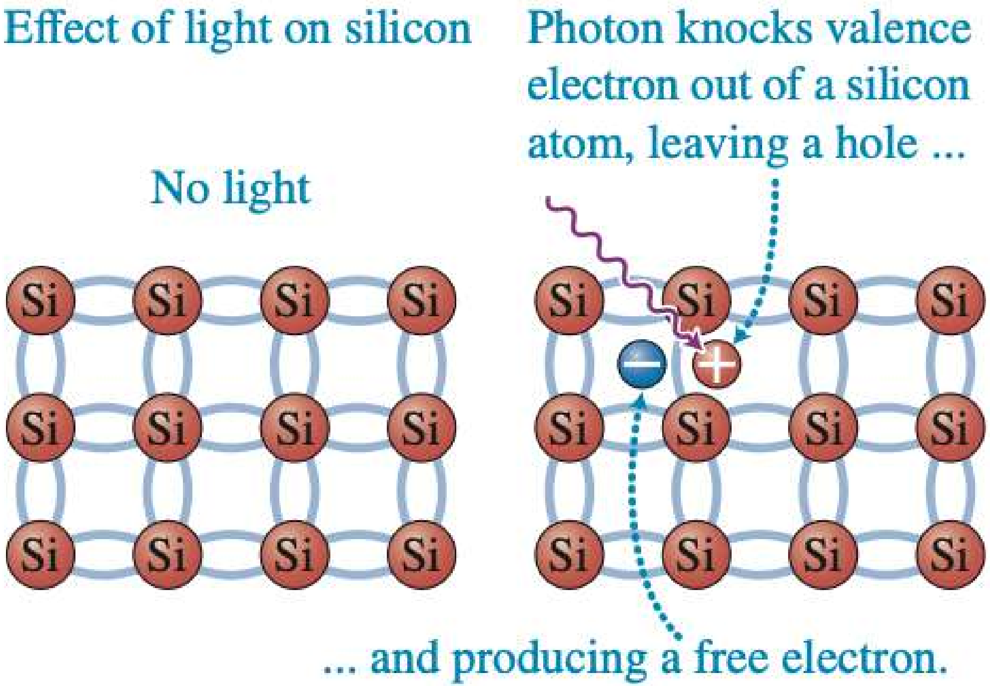
How to enact internal structure of metals?

FIGURE 19.6 (a) Free electrons drift randomly, moving fast between collisions but with no preferred direction. (b) When an electric field is present, the electrons continue this random motion but now drift toward the area of higher potential, opposite the direction of the $\vec{E}$ field.



How to enact free electrons and holes in a semiconductor? And the photoelectric effect?

FIGURE 27.15 Light shining light on silicon produces free electrons and "holes."



Mathematical representations

Ask for a volunteer to follow instructions from peers to enact:

x = -3 m + (2 m/s) t

What do you think they would do?

More complex mathematical representations

E field and V field

First - why the terms? What is E field and what is V field?

E field

TIP Equation (18.2) is an operational definition for the $\vec{E}$ field; the expression $E = k_C Q/r^2$ is the cause-effect relationship.

The $\vec{E}$ field is a physical quantity that characterizes properties of space around charged objects. To determine the $\vec{E}$ field at a specific location, place an object with a small positive test charge q_{test} at that location and measure the electric force exerted on that object. The $\vec{E}$ field at that location equals the ratio

$$\vec{E} = \frac{\vec{F}_{Q \text{ on } q_{\text{test}}}}{q_{\text{test}}} \tag{18.2}$$

and points in the direction of the electric force exerted on the positive test charge. The $\vec{E}$ field is independent of the test charge used to determine the field. The unit of the electric field is newtons per coulomb (N/C).

V field

V field (or electric potential) due to a single charge To determine the V field due to a single source charge at a specific location, place a test charge q_{test} at that location and determine the electric potential energy $U_{Qq_{\text{test}}}$ of a system consisting of the test charge and the source charge that creates the field. The V field at that location equals the ratio

$$V = \frac{U_{Qq_{\text{test}}}}{q_{\text{test}}} = \frac{k_C Q}{r} \qquad (18.6a)$$

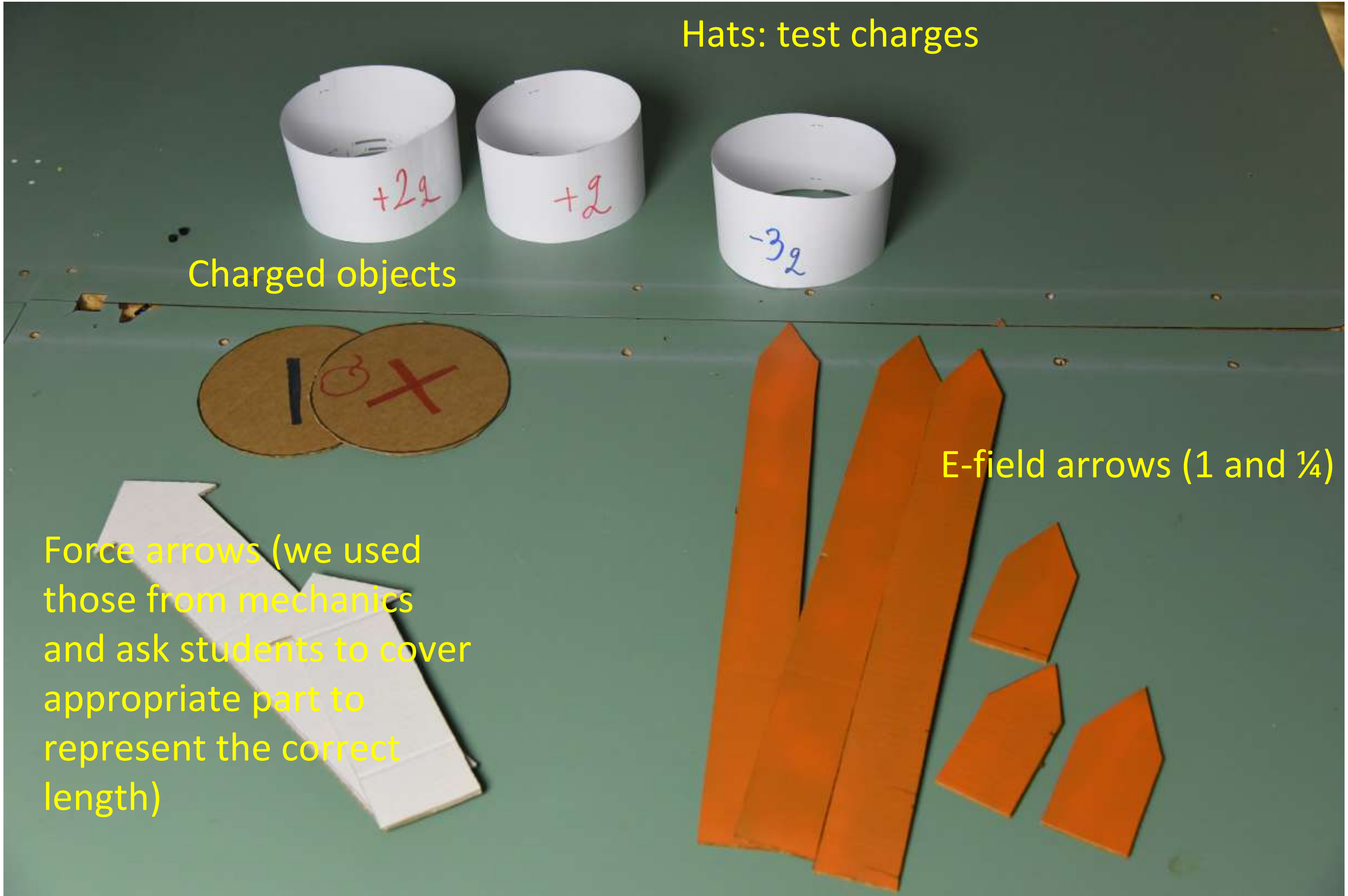
The unit of electric potential is joule/coulomb (J/C) and is called the **volt** (V).

We can also think of the V field at a specific location (let's say location A) as the ratio of the work that an external force needs to do on a positive test charge q_{test} to bring it to the location A from infinity and that charge:

$$V_A = \frac{W_{\text{from } \infty \text{ to A}}}{q_{\text{test}}} \qquad (18.6b)$$

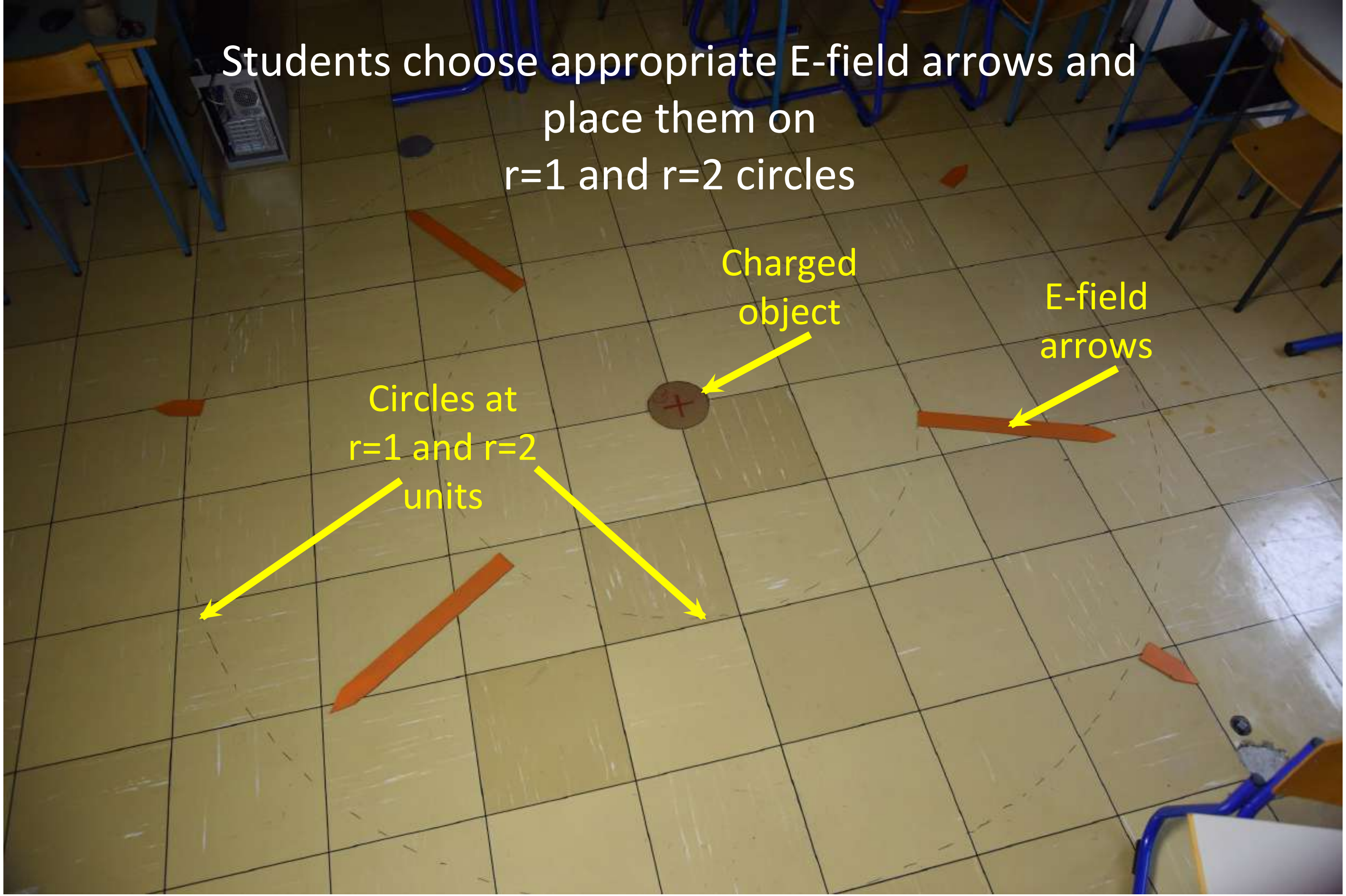
TIP

- Both the V field and the $\vec{E}$ field at a specific location are independent of the test charge and characterize the properties of space at that location.
- Unlike the $\vec{E}$ field, which is a vector quantity, the V field is a scalar quantity with a sign that depends on the sign of the charge that creates it.


Hats: test charges
+2q
+q
-3q
Charged objects
E-field arrows (1 and ¼)
Force arrows (we used those from mechanics and ask students to cover appropriate part to represent the correct length)

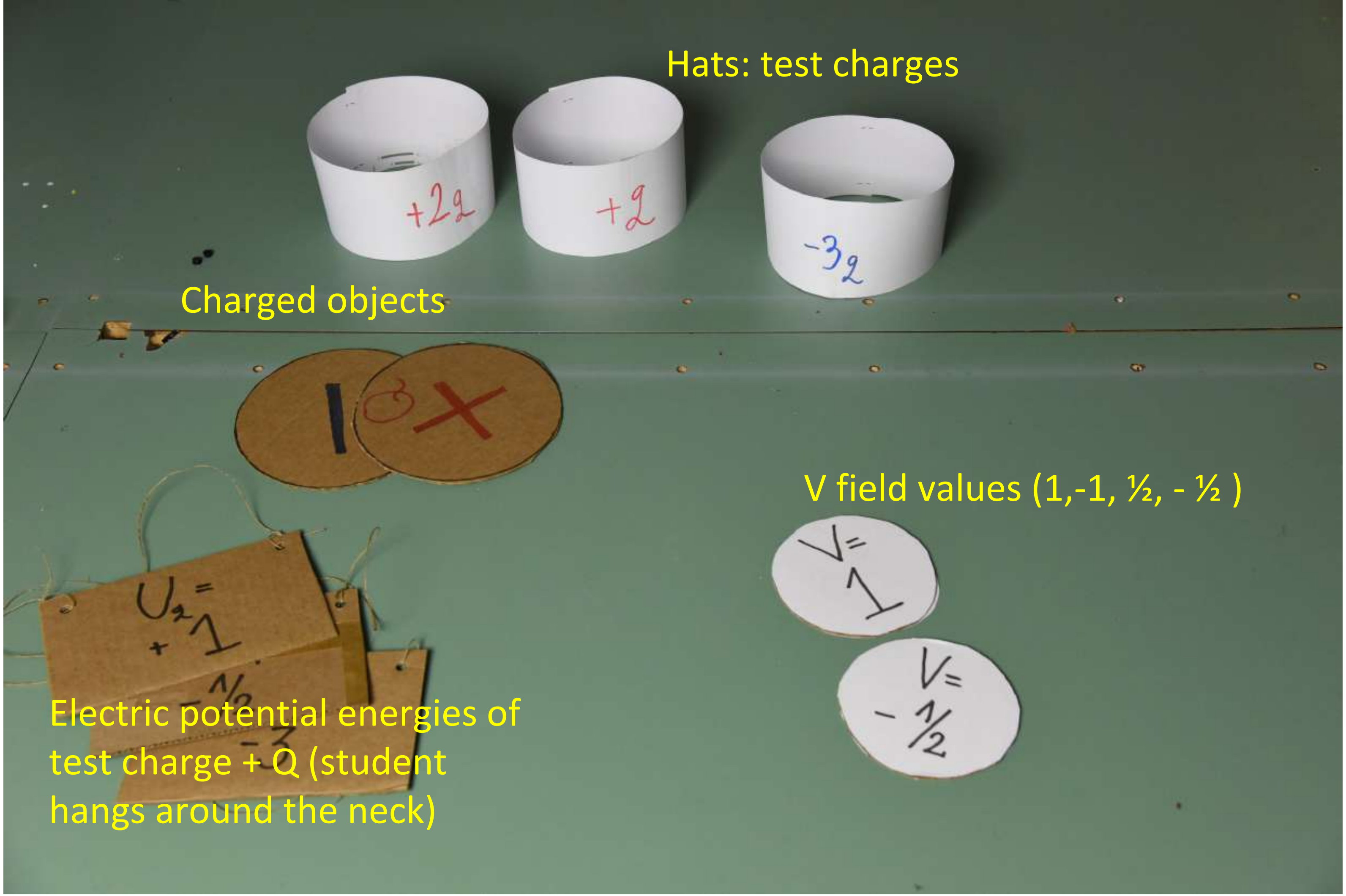
Place charged object +Q on the floor
Test charge +q (student) stands on r = 1; what is the force exerted on it?
Test charge +2q (student) stands on r = 1; what is the force exerted on it?
Force depends on test charge but $|F|/q_T$ does not; it depends only on Q and location in space
New quantity $E = |F|/q_T$ & agreement for the direction.
Students choose appropriate E-field arrows and place them on r = 1 and r = 2 circles (see photo on the next slide)

Same for –Q charged object


Students choose appropriate E-field arrows and place them on
r=1 and r=2 circles
Charged object
E-field arrows
Circles at r=1 and r=2 units

What is the benefit of having the *E*-field?
In many cases we don’t know the charges that produce electric field, we only know the *E*-field.
In this case we can determine the force exerted on arbitrary charge *q*’ when placed at a particular point only by knowing *q*’ and the *E*-field in that particular point (see photo on the next slide)

Take -3*q* charge (student) and ask her to choose a place (r =1 or r = 2). Others determine the direction and relative size of the force exerted by the source change on -3*q.*



Hats: test charges

Charged objects

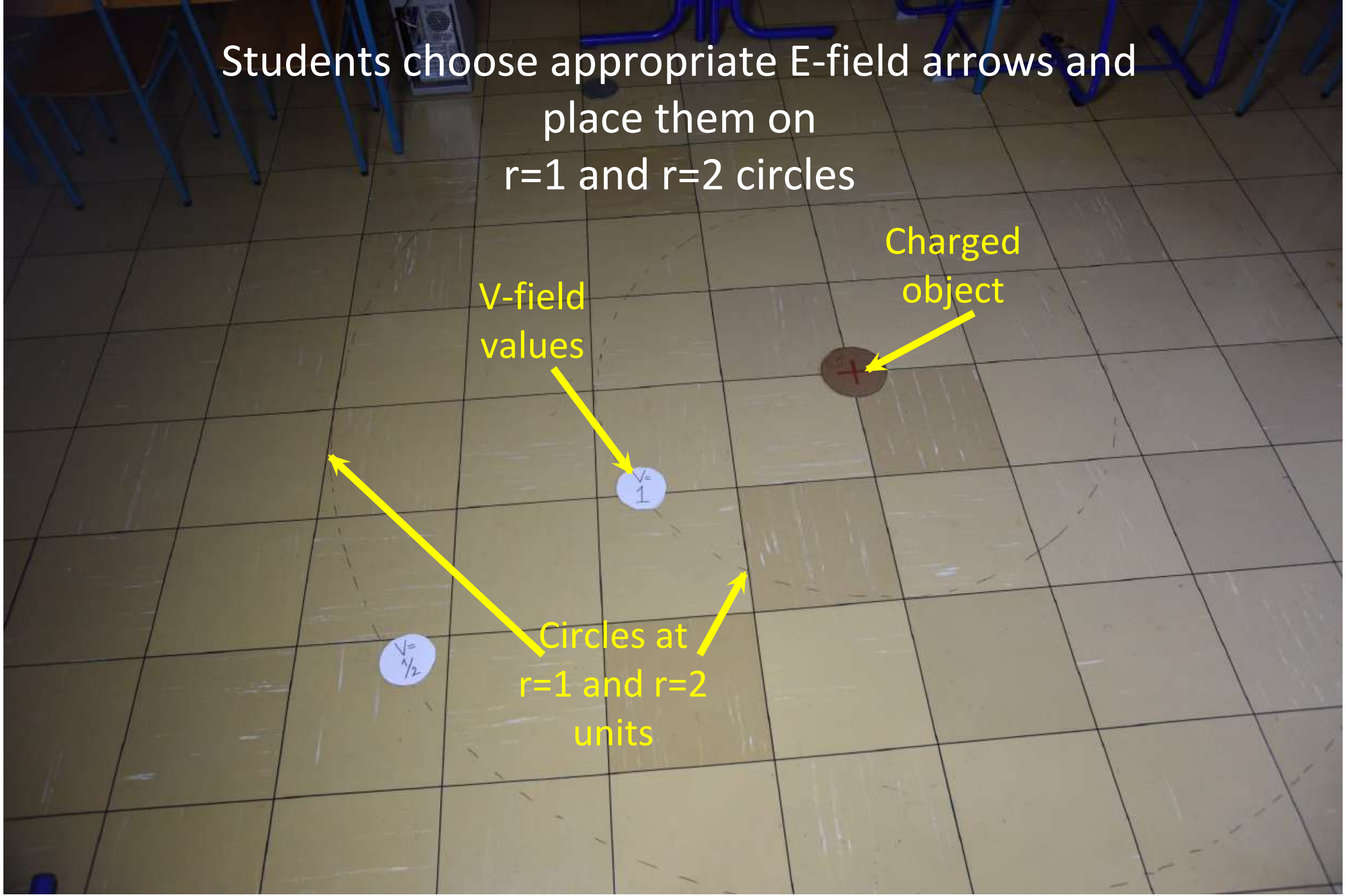
V field values (1,-1, ½, - ½)

Electric potential energies of test charge + Q (student hangs around the neck)

Place charged object $+Q$ on the floor
System: test charge + charged object
Test charge $+q$ (student) stands on $r = 1$; what is the U_q energy of the system?
Test charge +2q (student) stands on r=1; what is the U_q energy of the system?
U_q energy depends on test charge but $|U|/q\_T$ does not; it depends only on Q and location in space
New quantity $V = U/q\_T$. The new quantity is scalar!
Students choose appropriate V-field values and place them on $r = 1$ and $r = 2$ circles (see photo on the next slide)

Same for $–Q$ charged object

Students choose appropriate E-field arrows and place them on r=1 and r=2 circles



What is the benefit of having *V*-field?
In many cases we don't know the charges that produce electric field, we only know the *V*-field values in space.
In this case we can determine the energy of the system arbitrary charge *q'* - electric field at particular place only by knowing q' and the *V*-field in that particular point of a space (the system is *q'* and the *V*-field – also *q'* and all charges that produce *V*-field). The *V* –field also helps us determine work done on q' when we move it from point A to point B in the space.

You need two students. Student 1 (charge -3*q*) stands at *r* = 1. Student 2 is "person outside the system". Ask students to enact the situation in which student 2 moves charge -3*q* from *r* = 1 to *r* = 2.