CSAAPT
Falls Church Meeting
Oct 22 2022

Free Physics Toys For K12 Teachers

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If would like a something, fill out the form while I am talking

- Purpose of the talk is to hand out free physics toys K12 teachers.
- Left over from project that created over 500 activities for workshops given in the summer from 2012 to 2015 at UVa in Charlottesville and JLab in Newport
- Co-PI's on the project were Frackson Mumba and Jennifer Maeng from Curry School of Education, and the Science Education group at Jefferson Lab.
- Workshops focused on energy, electricity, magnetism, light and optics. The school of education emphasized the teachers to follow a pattern of prediction, observation, and explanation.
- Here is a link for explanation and sample Lab write-ups for todays 113 items
- Demonstrate some selected materials
    - Static electricity activities
    - Electroscope activities
    - Van de Graaff stick and levitation

List of Activities for physical science/physics Grades 6-12

Items

- 11 Gel heating pad with thermometer — Activity 1
- 18 Dippy Duck Activity — Activity 2
- 16 Piezo popper Activity — Activity 3
- 12 Solar Racer Activity+Solar Dancer — Activity 4
- 12 Charging/spinner kit — Activity 5
  - 2 teflon rods, 2 acrylic, 1 wood, 1 silk cloth
- 16 Electroscope kit — Activity 6
  - 1 electroscope with base, 2 tubes with pins, 2 tubes without hole, 1 silk cloth
  - 1 Teflon rod, 1 acrylic rod, 1 protractor
- 28 Van de Graaff sticks with levitating foils — Activity 7
  - 1 VDG stick, 2 batteries, book of foils, 1 screen, 1firefly cannister

Total 113

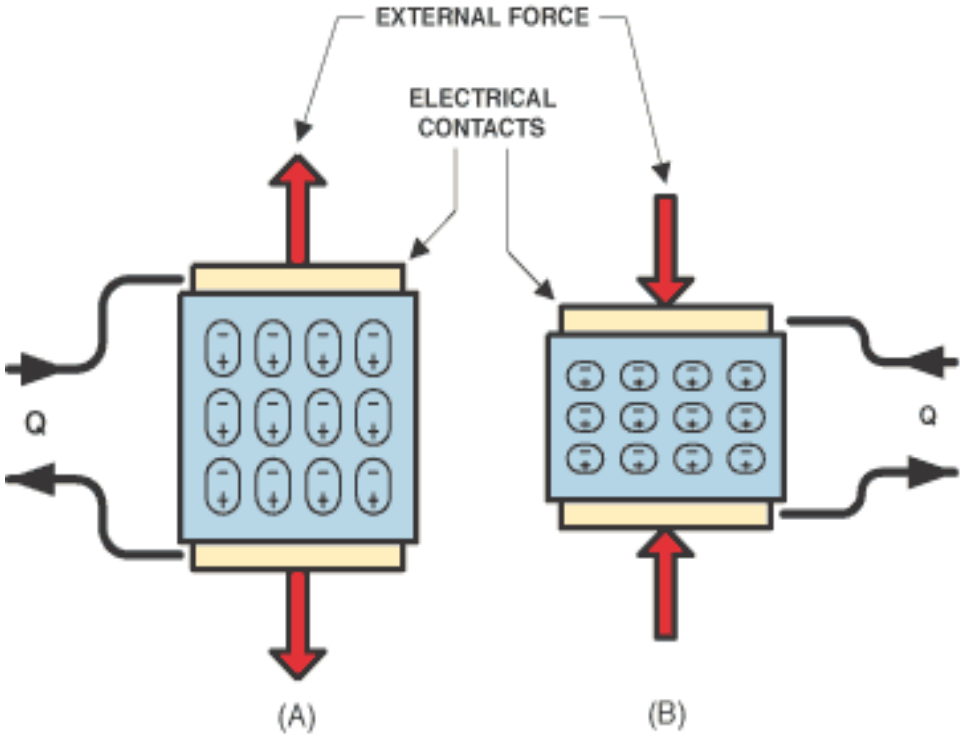
http://discovery.phys.virginia.edu/~ral5q/csaapt/

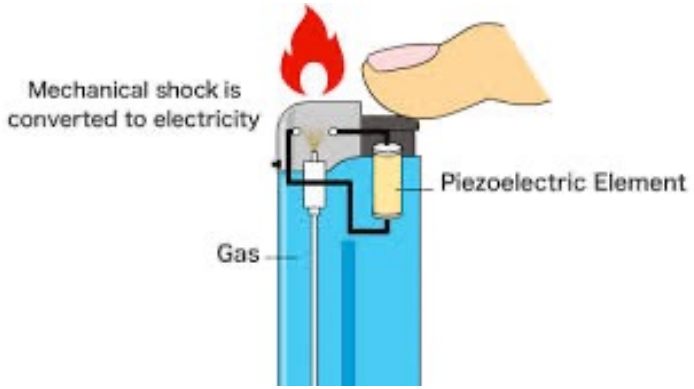
Activity 1: Gel heating pad (11) - K12

- Keep your hands warm.
- Pad contains a super cooled liquid called - sodium acetate.
- After you mechanically flex the disk in the the liquid, it crystalizes and releases heat of fusion up to 58 C.
- It last for 15-29 minutes
- Submerge pad in boiling in water bath for a few minutes to rejuvenate pad to use again.
- Mechanical energy gets transformed into thermal energy

Activity 2: Piezo-popper Activity (18) - Grades 9-12

- Some crystals (called piezoelectric) when they undergo a force such as tension (A) become electrically polarized producing a high voltage
- This spark will ignite a combustible fluid producing a flame as in a lighter.
- In the piezo-popper rubbing alcohol is used for the combustible gas
- Mechanical energy is converted to electrical energy and then back to mechanical energy.
-



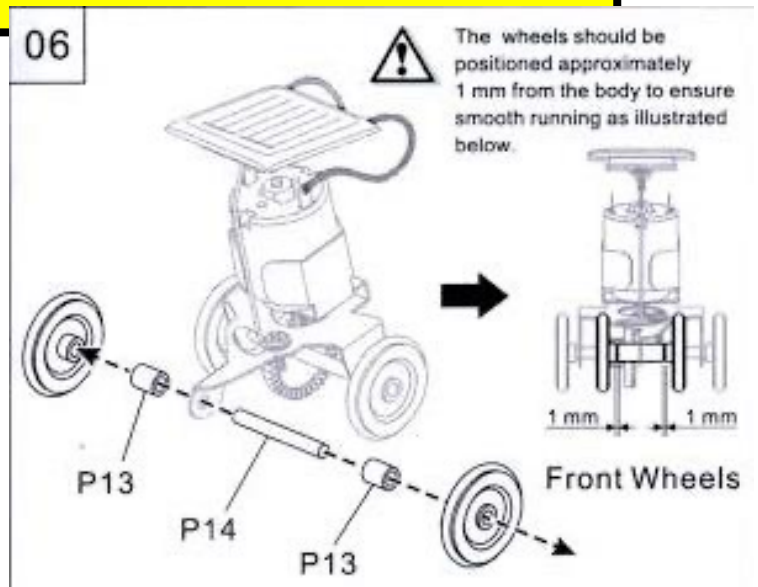


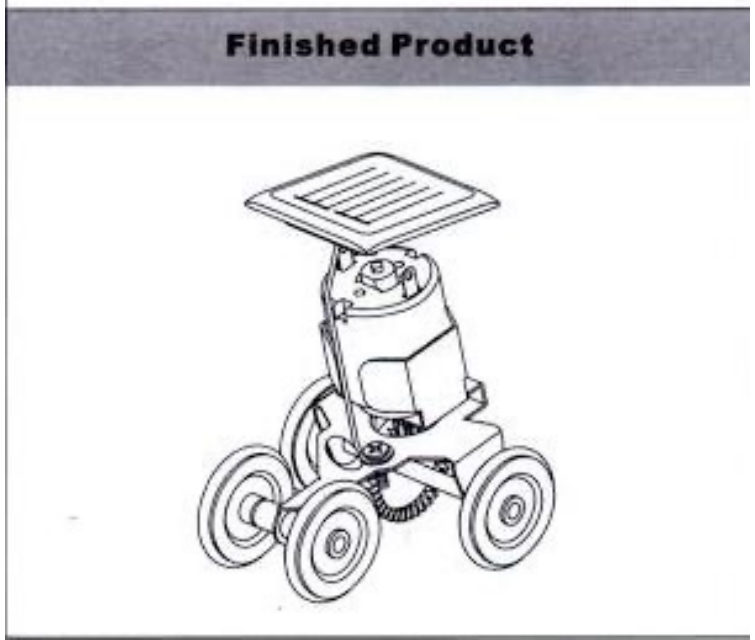
Activity 3: Dippy Duck Activity(16) – Grades 6-12

- Dippy Duck is a heat engine that uses thermal energy from the air that makes the head bob up and down like in perpetual motion.
- The liquid in the tube is methylene chloride which has a boing point very close to room temperature.
- Once the head is wet, water will evaporate and cool the head down. converting some vapor to liquid lowering the gas pressure.
- Some of the methlene chloride vapor will change to liquid lowering the pressure in the head causing the liquid to rise up the tube and the head to fall.
- The process then repeats itself.

Activity 4: Solar Race Car(12) – Grades 6 -12

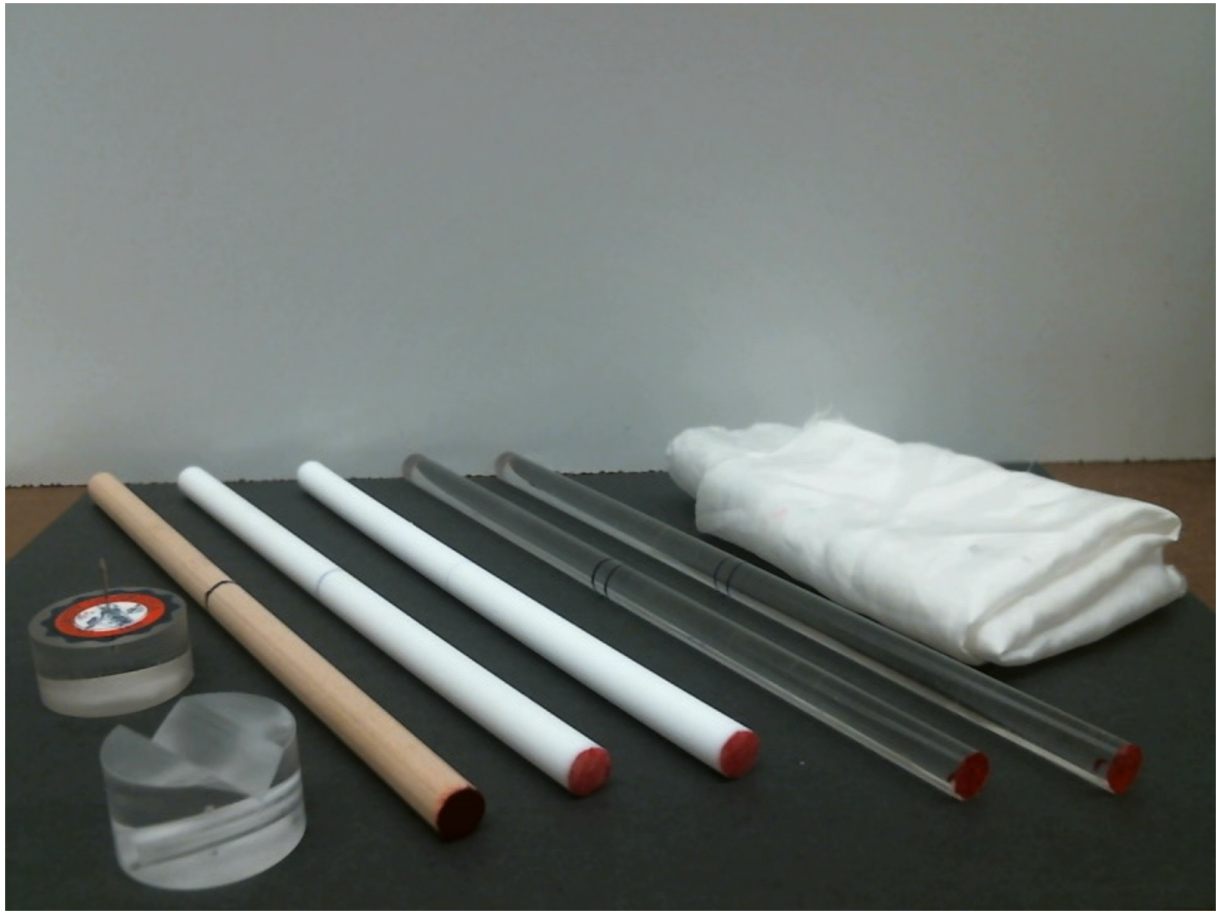
- The solar race car comes in pieces that you assemble including a solar to electric current converter. Some of the pieces are shown in the figure.
- The current runs a small motor that is coupled to the wheels with plastic gears.
- Solar energy in this case is converted to electrical and then to mechanical to make the cart move.
- There is no battery.
- Here are some extra solar dancers.





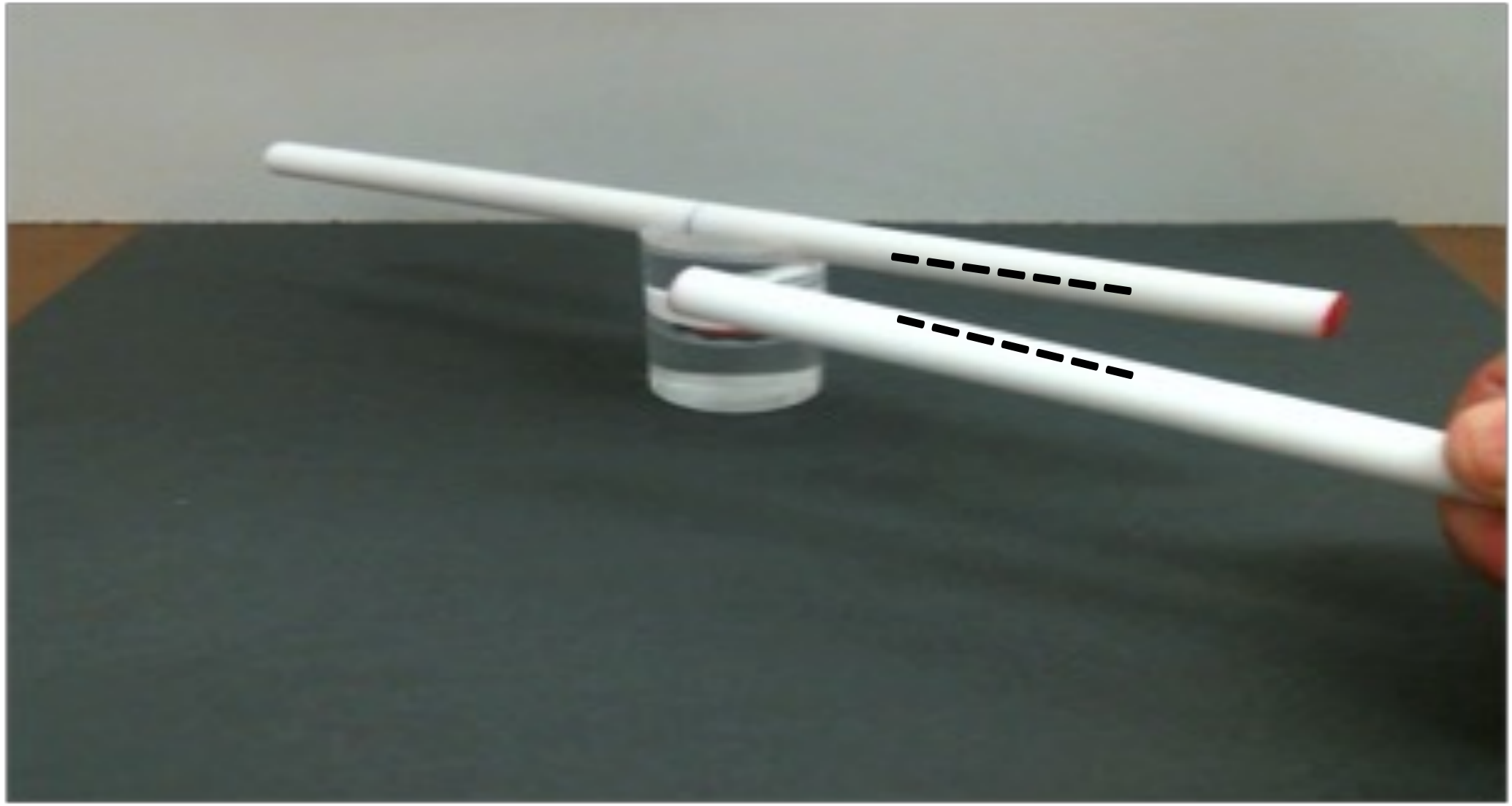
Activity 5: Charging Kit (12) Grades 9-12

- Teflon rods gain excess electrons when rubbed with silk. Silk loses electrons and becomes positive.
- Acrylic rods loses electrons when rubbed with silk and become positive.
- Wood rod is not charged when rubbed with silk.
- Show repulsion and attraction placing one charged rod on rotating holder and holding another charged rod in hand.
- Also show induced polarization using uncharged objects.



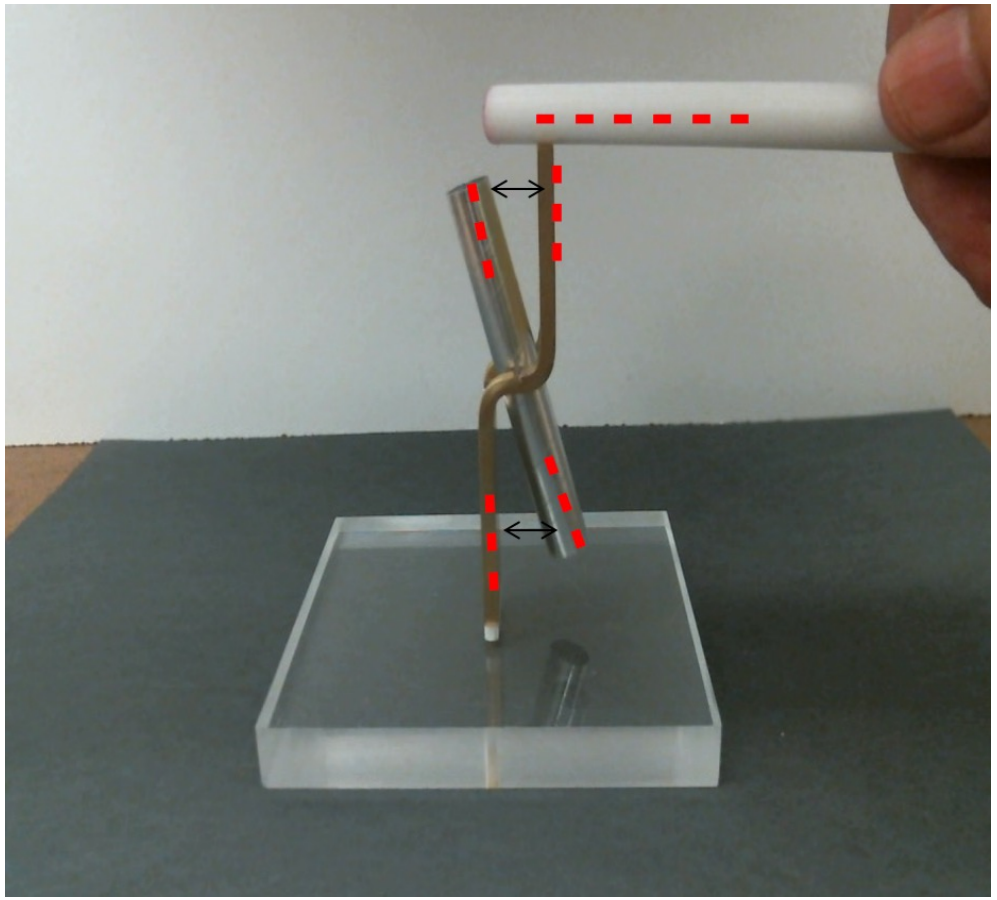
- 2 Teflon rods, 2 acrylic rods, 1 wooden rod, silk cloth, spinner

Showing like charges repel



Activity 6: Electroscope Kit (16) Grades 9-12

- A negatively charged Teflon rod touches the top of the brass support.
- On the top half repulsive forces between the electrons in the brass and tube create a torque about the pivot point and rotate the tube CCW.
- The axis of rotation is about the pin inserted through the tube offset from the c.m. of the tube by about 2 mm.
- The tube rotates CCW until it is balance by the opposing gravitational torque produced by the added mass due to the longer lower half of the tube.

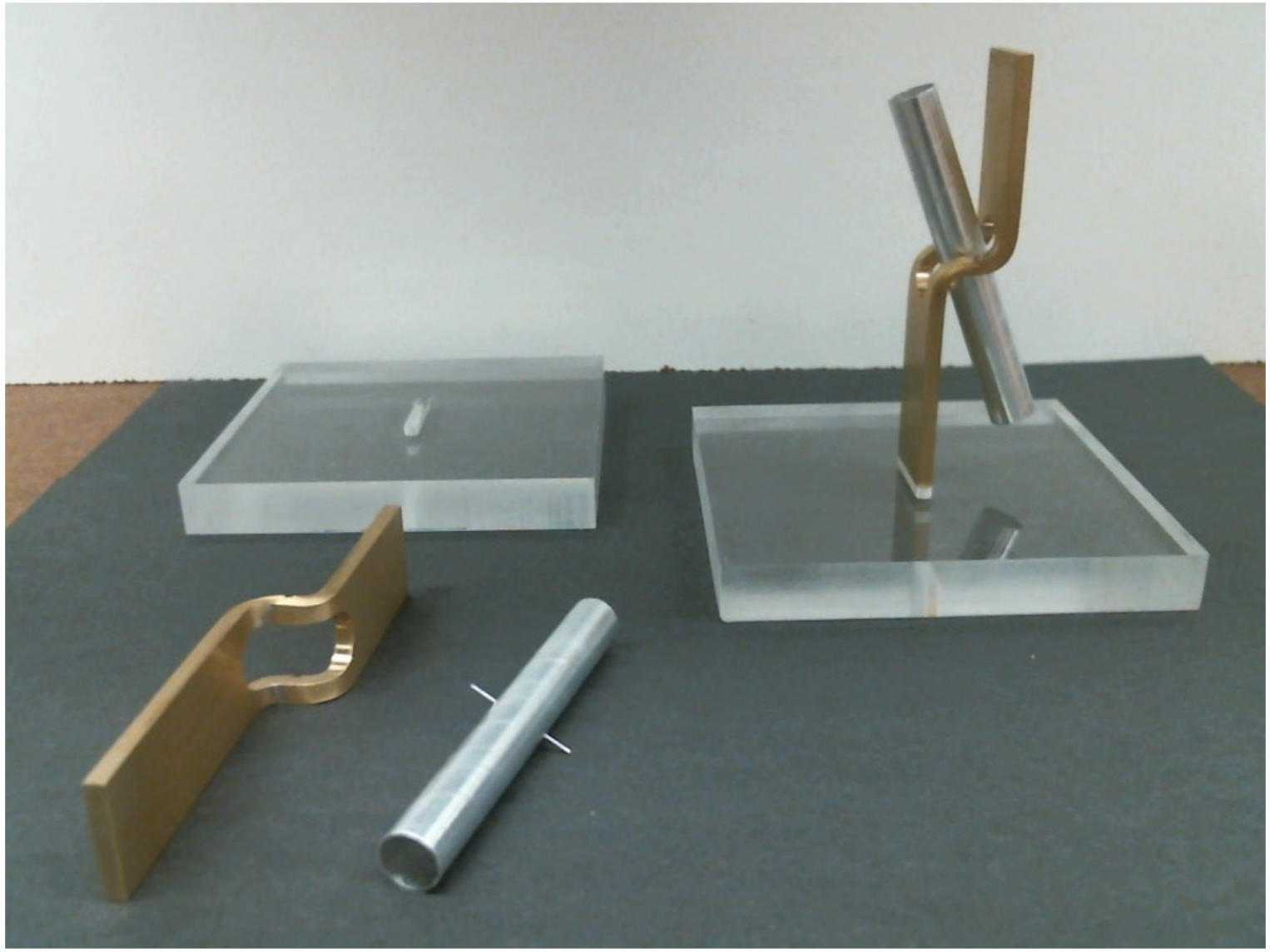


1 Electroscope 1 teflon rod, 1 acrylic rod, and silk cloth

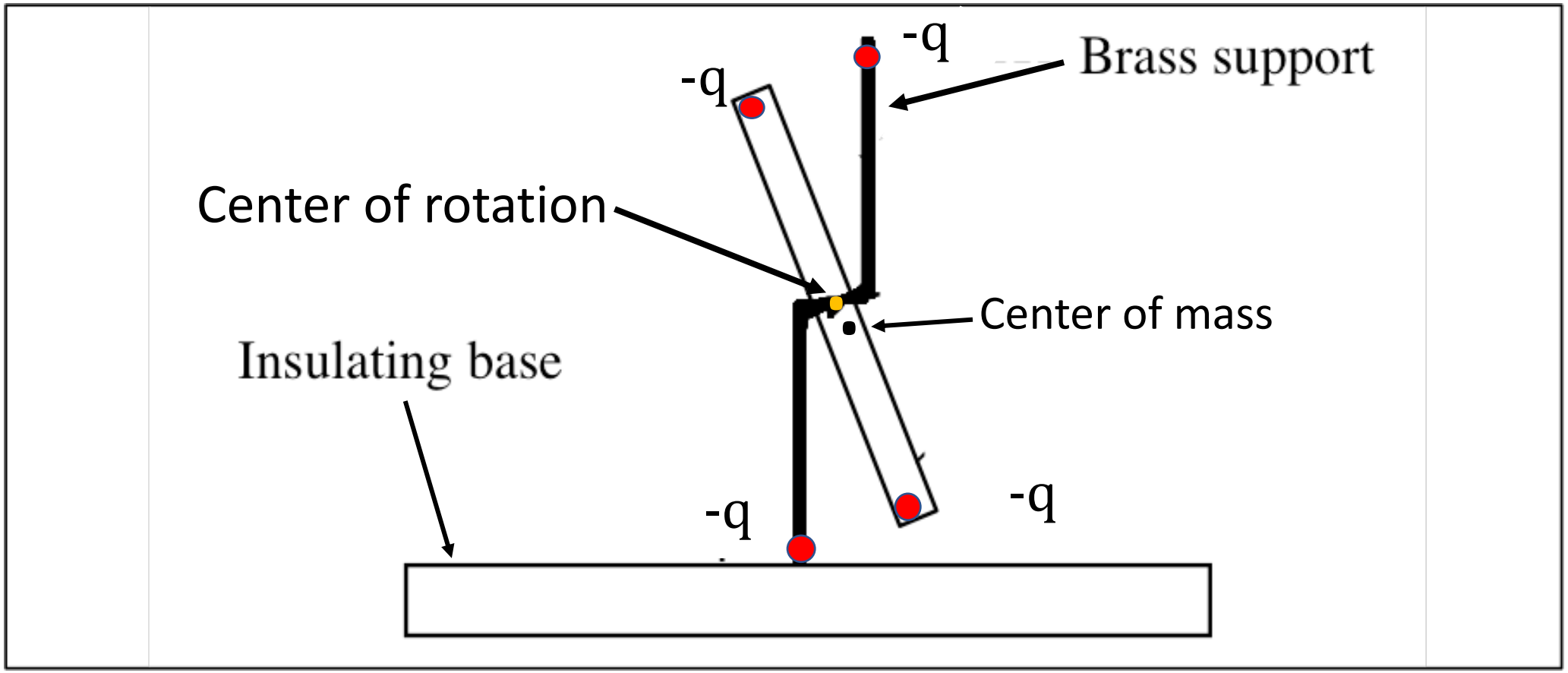
Activity 7: Van der Graaff Stick (28) Grades 9-12

- Until you look closely at the construction you can hardly believe this is a Van de Graaff generator
- Test it out levitating conducting foils and pie tins. Foils come with it but not the pie tins.
- Determine the polarity of the VDG using the electroscope or or rotating Teflon holder
- Convert the voltage to light energy using the electric firefly

Electroscope Construction

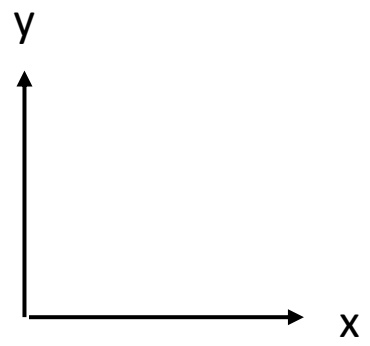


Model 1 -Four Equal Point Charges



This is a very unrealistic model of the charge distribution, but it is much simpler to explain what is happening assuming point charges.

Point Charge Model of Electroscope

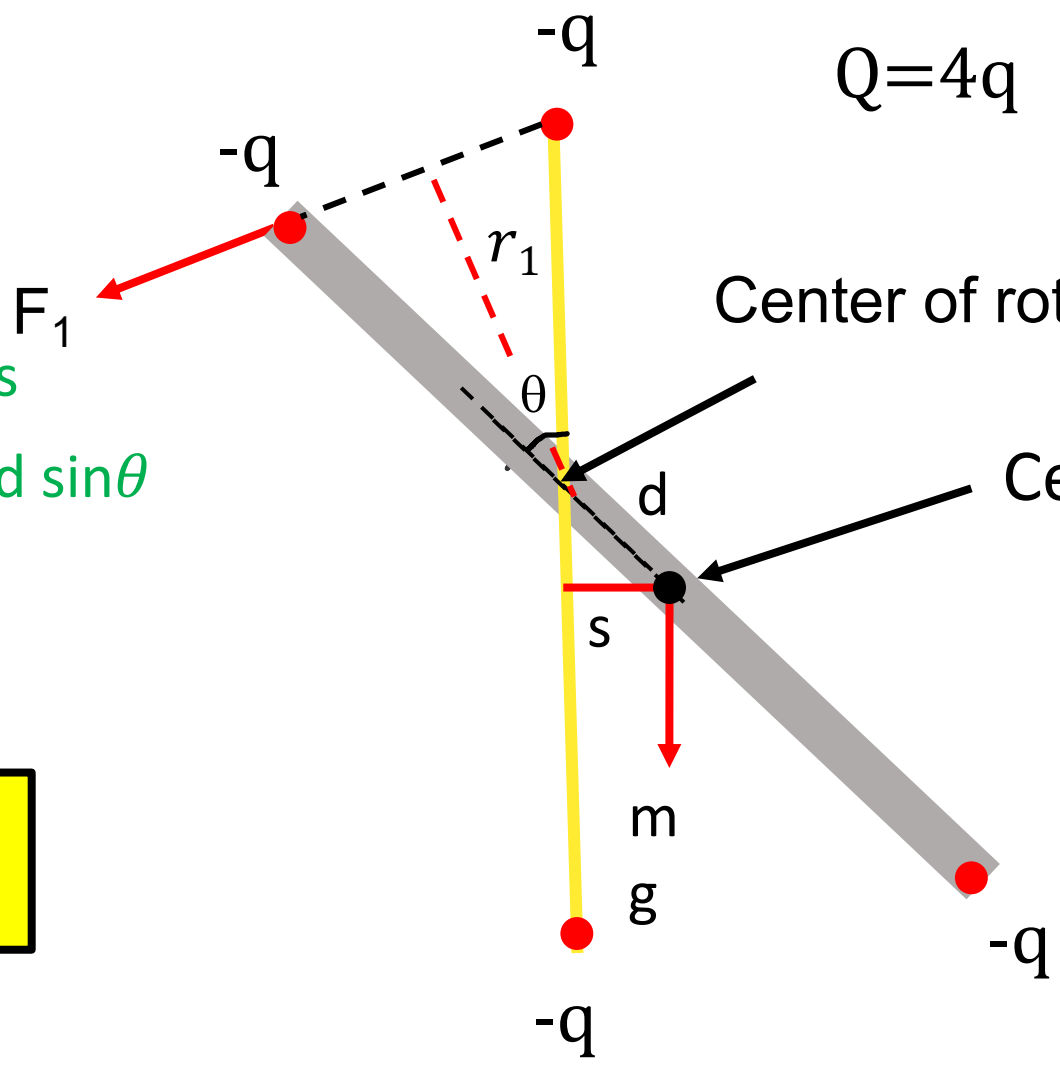


$Torque = 2\ F_1\ r_1 = mg\ s$

$2\left(\frac{kq^2}{L^2\sin(\frac{\theta}{2})^2}\right)\frac{L}{2}\cos(\frac{\theta}{2}) = mg\ d\ \sin\theta$

$$Q = 4\sqrt{\left(\frac{2mgdL}{k}\right)}\sqrt{sin^3(\frac{\theta}{2})}$$

$$\boxed{Q = 48\sqrt{sin^3(\frac{\theta}{2})}\ nC}$$

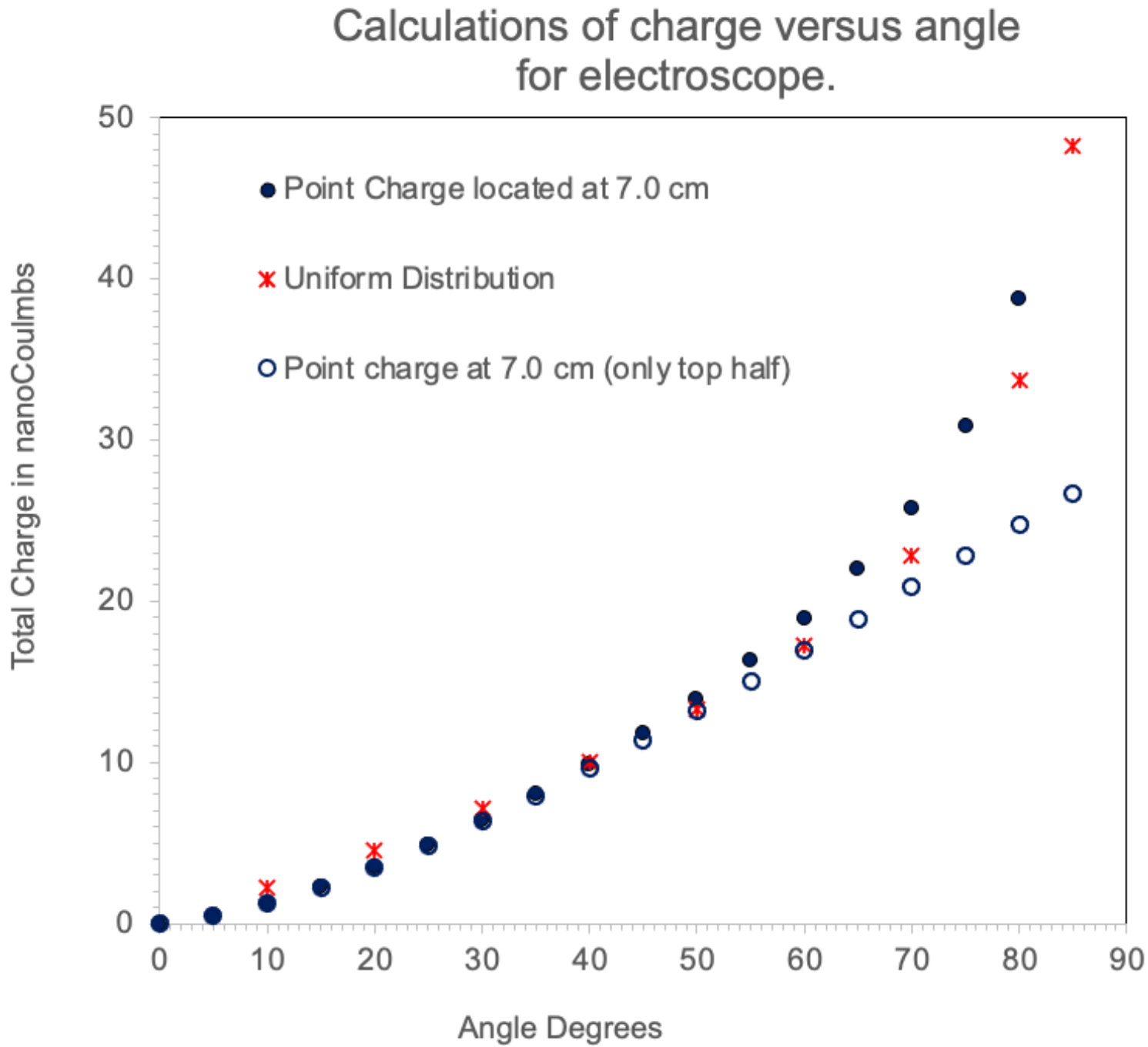


$Q = 4q$

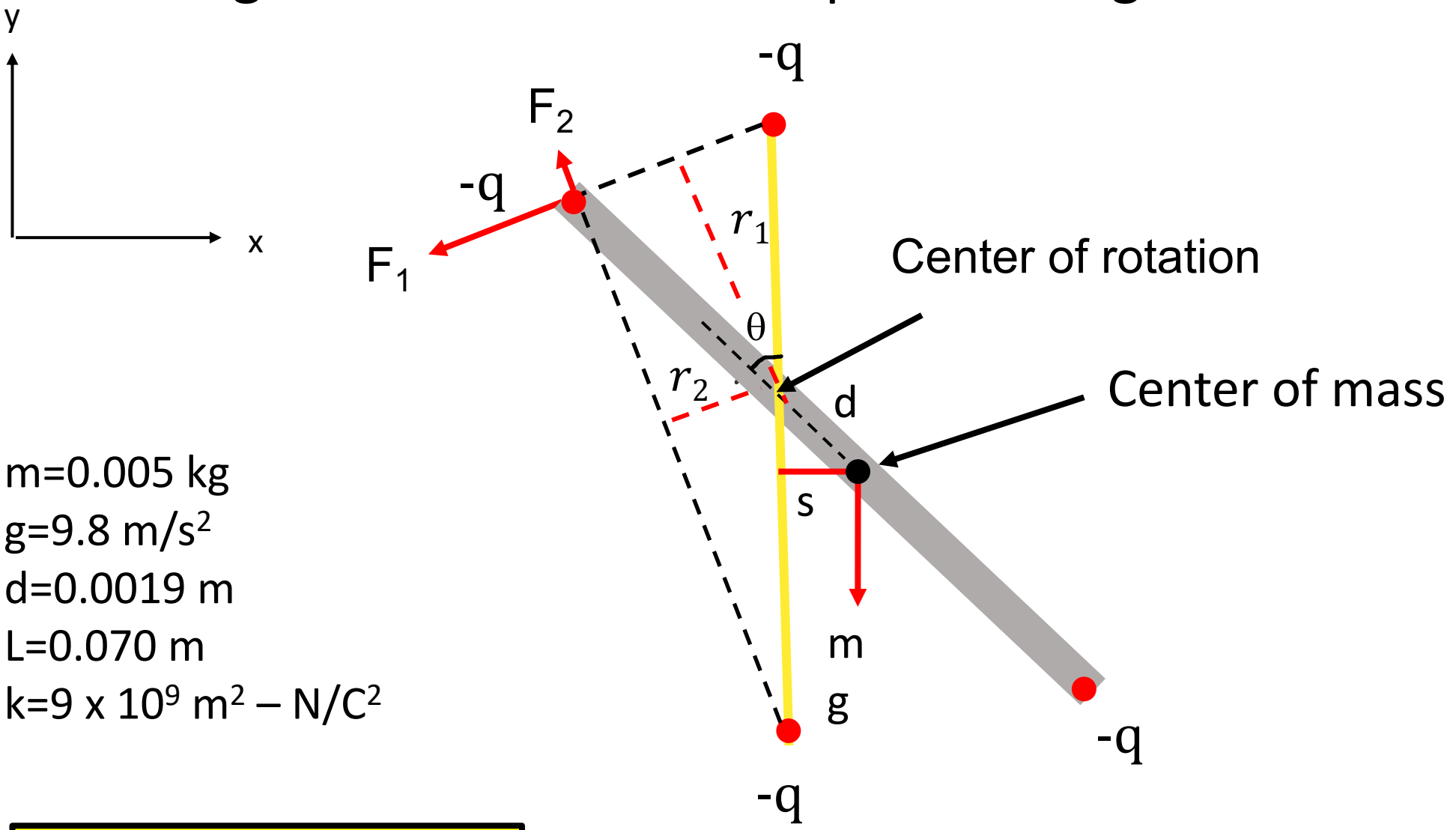
Q is the total charge

Center of rotation

Center of mass


Calculations of charge versus angle for electroscope.
Point Charge located at 7.0 cm
Uniform Distribution
Point charge at 7.0 cm (only top half)
Total Charge in nanoCoulmbs
Angle Degrees
0
10
20
30
40
50
60
70
80
90

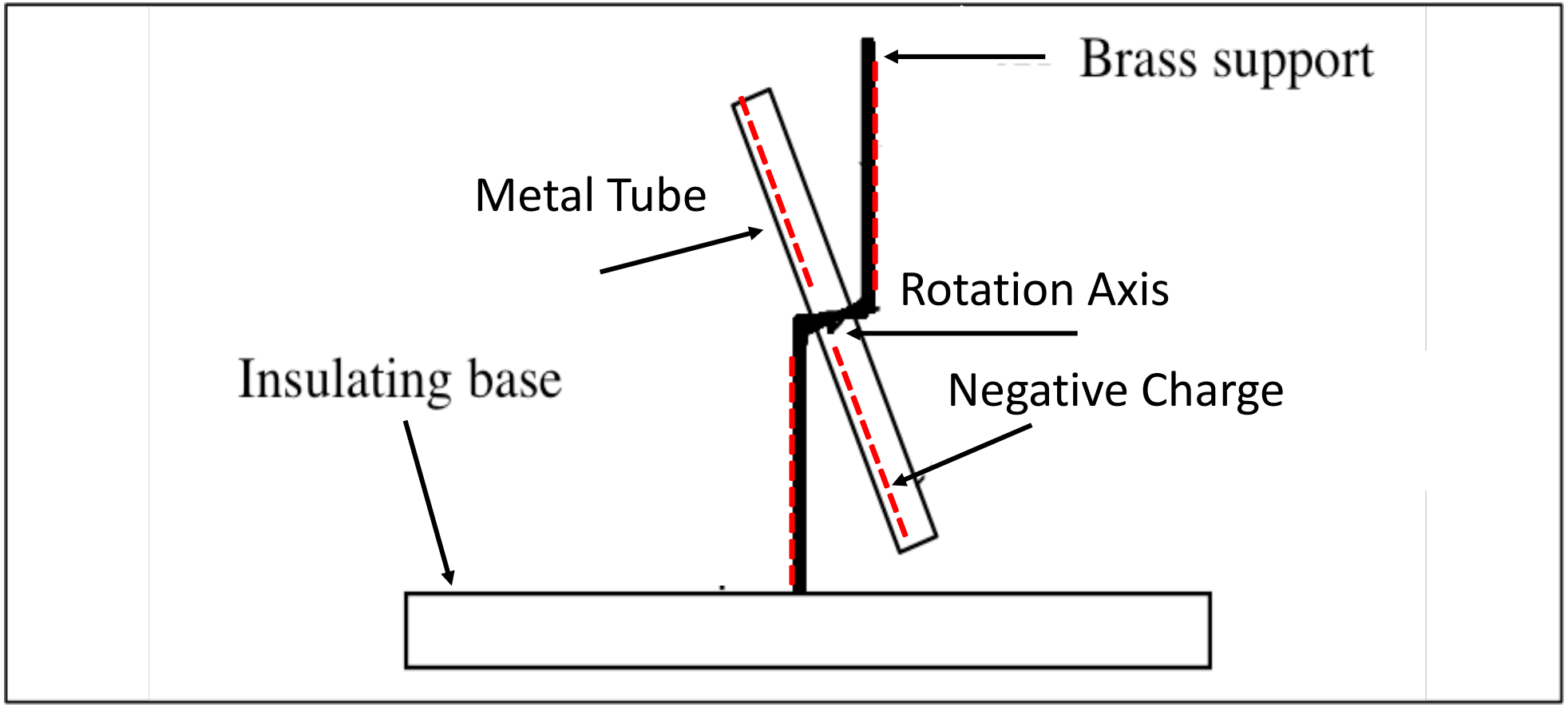
Point Charge Model of Electroscope including bottom charge



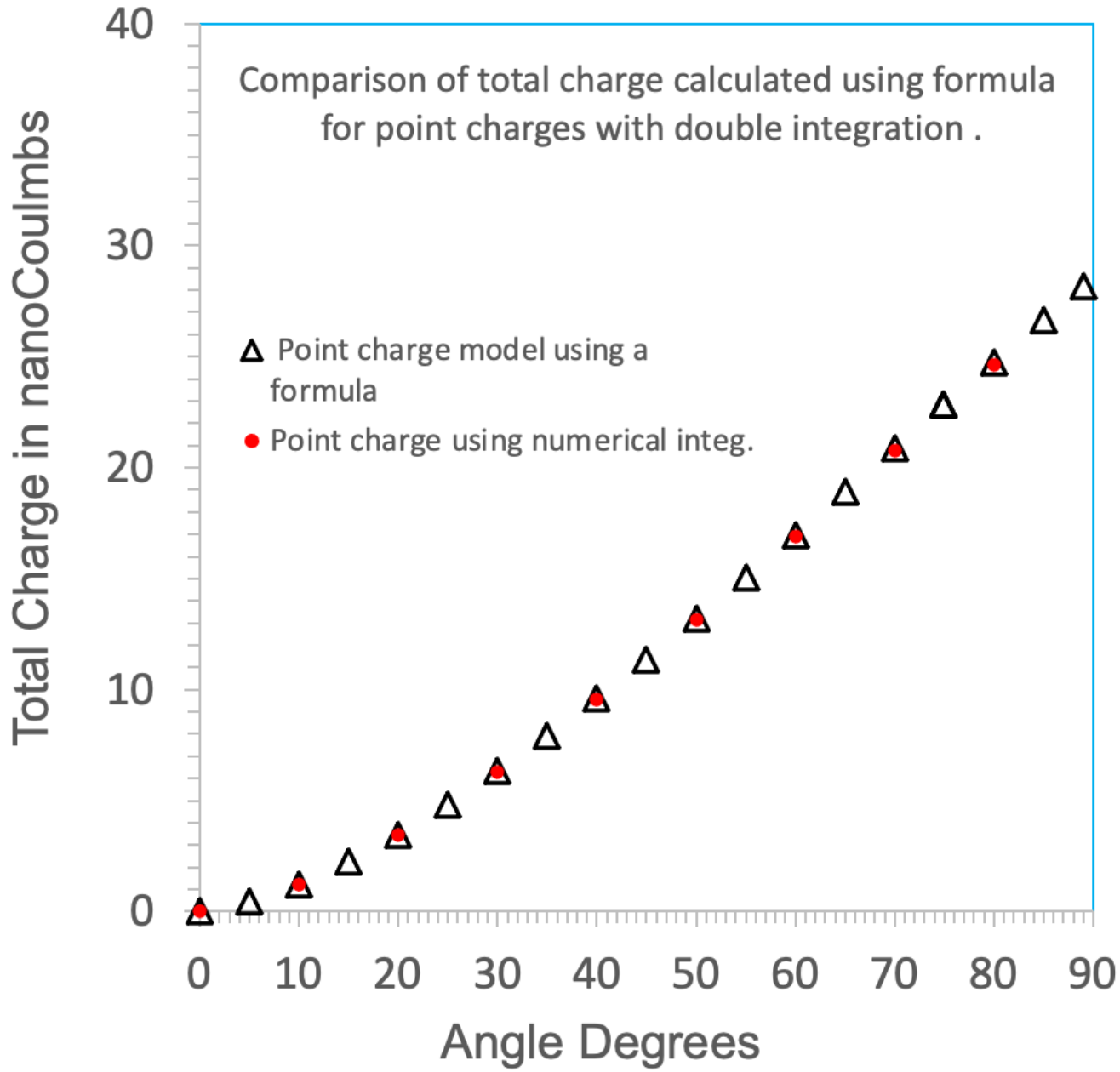
m=0.005 kg
g=9.8 m/s^2
d=0.0019 m
L=0.070 m
k=9 x 10^9 m^2 – N/C^2

$$Q=48\sqrt{\left(\frac{sin^3(\frac{\theta}{2})}{1-tan^3(\frac{\theta}{2})}\right)}\ \text{nC}$$

Uniform Negatively Charged Tube and Brass Support



Numerical Integration


Comparison of total charge calculated using formula for point charges with double integration .
Point charge model using a formula
Point charge using numerical integ.
Total Charge in nanoCoulmbs
Angle Degrees
0
10
20
30
40
0
10
20
30
40
50
60
70
80
90

List of Activities for physical science/physics Grades 6-12

11 Activity 1: Gel heating pad with thermometer
18 Activity 2: Dippy Duck Activity
16 Activity 3: Piezo popper Activity
12 Activity 4: Solar Racer Activity+Solar Dancer
12 Activity 5: Charging Objects by Rubbing
- Activity 5-1: Charging Objects by Rubbing
- Activity 5-2: Electrical Forces between Charged Objects

16 Activity 6 : Electroscope
- Activity 6 - 1: Using electroscope to detect the presence of charge
- Activity 6 - 2: Conductor or Insulator?
- Activity 6 - 3: Adding positive charge to negative charge
- Activity 6 - 4: Movement of Charges in a Conductor

28 Activity 7 : Van de Graaff Wunderama Stick
- Activity 7-1: Determine Polarity of Charge of the Van de Graaff
- Activity 7-2: Mini-Pie Plates
- Activity 7-3 Electric Levitation
- Activity 7-4: Poor Mans Faraday Cage
- Activity 7-5 Electric Firefly

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Energy Conversion and Electrostatic Activities using Simple Toy-Like Devices Available Free to Attending Teachers

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Abstract for a Talk for
American Association of Physics Teachers
Chesapeake Sectional Meeting (CSAAPT) at the
Virginia Tech Northern Virginia Center
Falls Church, Virginia
October 22, 2022

Summer workshops spearheaded by the Department of Physics in collaboration with the Curry School of Education at the University of Virginia and with Jefferson Laboratory in Newport News developed activities for secondary physics and physical science teachers to use in their classrooms. Specifically, energy, electricity, magnetism, light and optics were the subject areas. In this presentation we will discuss the physics/pedagogy for several energy and electrostatics activities and make available(free) materials needed to conduct these activities including a lesson plan on the specific activity. These are very rudimentary instructions and you are obviously free to develop any set of instructions as you see fit. For the taking, there will be approximately 10 super-cooled gel heating pads; 16 dippy ducks; 14 piezo poppers; 12 build your own solar race cars; 12 electric charging kits with Teflon rods, acrylic rods, almost frictionless rotating holder, and silk cloth; 12 electroscope kits with an almost unbreakable, rugged, portable electroscope holder, 2 charging rods, and silk cloth; and 26 Van de Graaf Wanderama sticks. Selected examples of such activities will be presented and demonstrated focusing mostly on the home-made electrostatic activities. After discussion teachers will be allowed to peruse the activities and take at least 1 item home. You may be permitted to select as many as 2 items if all items are not first exhausted by the attending teachers.