

# PBL: Playing W/Charges

## 活動單元：電荷

By Jonathon David White

	Name	IDs								Team Name
Driver										
Co-driver										

### 0. Introduction 簡介

在這個單元，你要處理基本電子在四個不同物理學領域的模擬實驗，在你的團隊開始作答問題前，玩玩看每個模擬實驗，熟悉每個模擬實驗的操作，並利用這些模擬來回答問題。

In this activity, you will perform virtual experiments with 4 public domain physics simulations exploring static electricity. Before your team starts answering the questions, play with each simulation. Get familiar with each of the buttons. Where there are tabs, utilize them.

### 1. Balloons and Static Electricity

A 下載模擬器 Download, Run and Play with the PhET Simulation: "Balloons". 3 materials (wool sweater, plastic balloon, wall) are used in this simulation. Only electrons are free to move.

#### B Observe

1. Reset the simulation to show all charges, the wall, and only 1 balloon. Rub the balloon on the wall. What happens? 重置氣球，將氣球在牆上摩擦，請敘述發生了什麼事?

2. Rub the balloon on the wool sweater. What happens? 將氣球在羊毛衣上磨擦，發生了什麼事?

3. What happens when the balloon touches the wall? Why? 此時將氣球靠近牆壁，會發生什麼事? 原因為何?

4. Release the balloon midway between the wall and the sweater. What happens? Why? 將此時的氣球在在牆壁和羊毛衣中間放開，會發生什麼事? 請解釋。

#### C Interpret

1. Make three conclusions based on the above experiment. (請位上述的實驗做出三個結論。)

### 2. Electrostatics & Electric Shocks 靜電學與觸電

A 下載模擬器 Download, Run and Play with the PhET Simulation: "John Travoltage".

#### B Observe

1. With John's hand far away from the door knob, move John's foot across the carpet. What happens? 先將約翰手遠離門把，再將腳在地上的地毯摩擦。發生了什麼事?

2. Stop moving John's foot across the floor. (a) How do they disperse themselves over his body? (b) Why do you think this happens? 停止摩擦地毯，請問負電荷到身體何處? 請描述帶電粒子在 John 身體裡的行為?

a	
b	

3. When you move his hand towards the door, what happens? 此時將手一道門把上，會發生什麼事？為什麼？

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4. With John's hand on the doorknob, rub John's foot on the floor. What happens? How does this differ from the case in question B.1 當約翰手放在門把上同時用腳摩擦地毯，會發生什麼事？


5. How can we maximize the amount of charge on John? 如何讓約翰身上充滿電荷？

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### C Experiment

1. Design an experiment to find the relationship between the excess number of negative charges on John Travolta and the closest his hand can come to the door without giving him an electric shock. Write down the algorithm (steps) of the experiment below: 請設計一個實驗找出在當約翰身上最多能有多少個電子卻不讓他的手在最接近門把的距離時不被電到？請在下方寫下實驗的步驟。


2. Perform the experiment you have designed. **a. Record** your data in the table. 實際操作你所設計的實驗並記錄數據。 **b. Graph** the data.. 畫出相關性。 **c. Propose** a mathematical expression relating the maximum charge that can stay on John Travoltage and the distance between his hand and the door knob. 使用數據，派生一個方程式表示，存在約翰身上最大量的"電荷量"與他手跟門把間的"距離"之間的關係。(Using a spread sheet program can aid in graphing and deriving the mathematical relationship 使用電子表格程序可以幫助繪製圖形並推導出數學關係 NOTE: Your final mathematical equation should be composed of a numerical constant (found from your data), q and r. There should be no other symbols in your equations.)

a. Data		b. Graph the data (線形圖)	c. Propose Mathematical Equation
q (charge)	r (separation)		

### D Think

1. In Taiwan when we rub our shoes on a carpet, we usually do not get an electric shock. Why is this the case? 為何我們在台灣摩擦地板時，不會觸電？

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2. During winter in Canada, it is very easy to get an electric shock as we walk **inside** across the carpet. Why do you think this happens? 在冬天走在地毯上為何容易引發觸電現象？請解釋。

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### 3. Playing with Electric forces 電子曲棍球：介紹電場

A 下載模擬器 Download, Run and Play with the PhET Simulation: "Electric Field Hockey" Start in practice mode. Your job is to place charges in position to get the puck (black) into the goal.

#### B Observe (Use Practice Mode)

1. Place a single negative charge so the put the puck goes into the net. Draw a picture showing where you have placed the charge. 將一個負電荷放在何處，可使冰球射入網中。註：冰球是負電荷



2. Place a single positive charge so the put the puck goes into the net. Draw a picture showing where you have placed the charge.(將一個正電荷放在何處，可使冰球射入網中。註：冰球是負電荷)



3. Turn on the Trace and the Electric Field Lines. Repeat questions 1 and 2. How does the direction of the motion of the puck relate to the direction of the electric field lines? 勾選軌跡和電場，重做問題一和二。請問冰球運動方向和電場方向的相關性為何?

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4. Increase the mass of the puck. How does this affect the motion of the puck? Can you express the relation in a mathematical equation? 增加冰球的質量，試問對冰球運動的影響。請解釋。


5. Change the charge on the puck from negative to positive. How does this change the motion and the relationship between the motion and the direction of the electric field lines? 將冰球換成帶正電，試問冰球的運動方向和電場方向的相關性為何?

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#### C Interpret

1. Summarize the factors that influence the motion of hockey puck. 請列出能影響球運動的因素?


2. Design and experiment to allow you to estimate the relationship between **force** (and acceleration) and the **separation** between a single charge and the puck.(你能否猜測 吸引或排斥的力 與 距離在數學上有什麼關係? 請設計一個實驗讓你可以估計力、加速度、電荷和冰球間的距離。)


3. Carry out the experiment you designed. **a. Record** your data in the table. 進行並在下面記錄你所設計的實驗結果。 **b. Graph** the relationship between F and r 畫出相關性。 **c. Propose** an mathematical equation relating the force on the puck and the distance between the puck and the point charge. 據觀察結果，寫下一個關於冰球上的力和冰球跟電荷之間的距離方程。(Using a spread sheet program can aid in graphing and deriving the mathematical relationship 使用電子表格程序可以幫助繪製圖形並推導出數學關係) NOTE: Your final mathematical equation should be composed of a numerical constant (found from your data), F and r. There should be no other symbols in your equations.

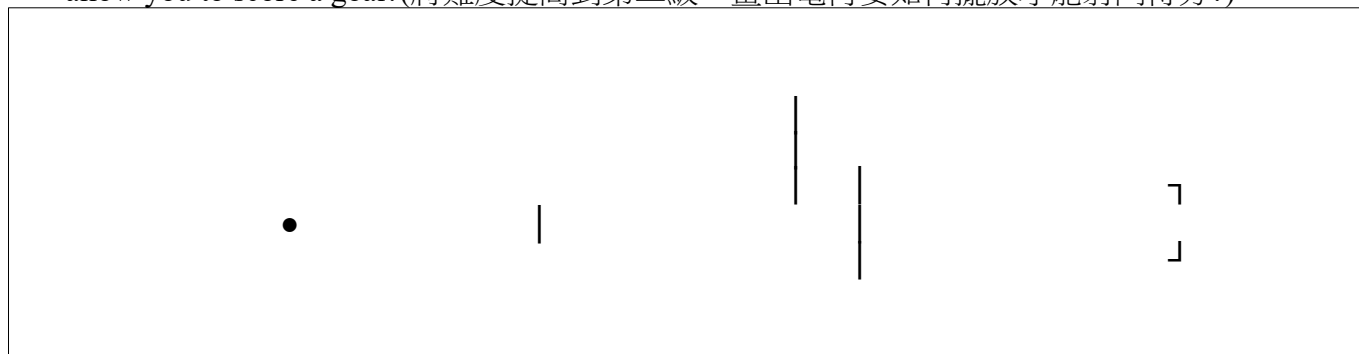
a. data			b. Graph (F vs r)	c. Mathematical Relationship
Measurement	r (separation)	F (force)		
1				
2				
3				
4				

#### D Enjoy: Play Hockey at Higher Levels

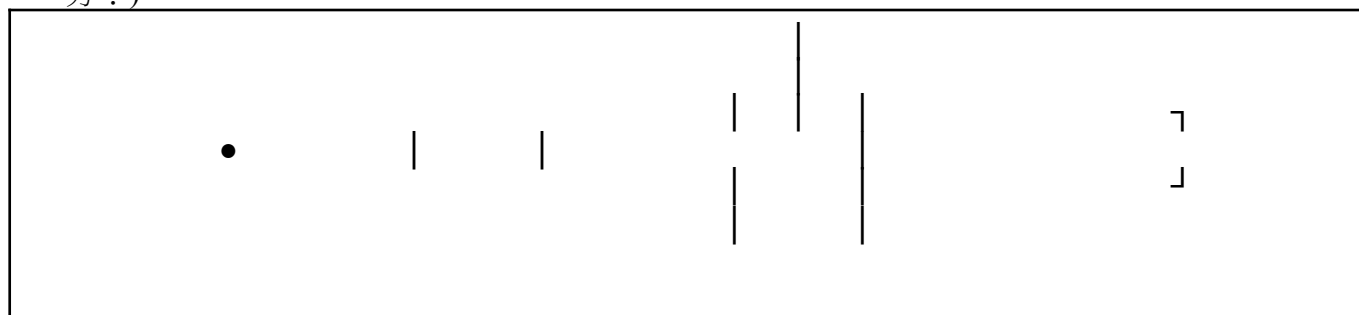
1. Increase the level of difficulty to level 1. Draw a picture showing where the charges are placed to allow you to score a goal? What sign charges did you use?(將難度提高到一級，畫出電荷要如何擺放才能射門得分?使用了什麼電荷?)



2. Increase the level of difficulty to level 2. Draw a picture showing where the charges are placed to allow you to score a goal?(將難度提高到第二級，畫出電荷要如何擺放才能射門得分?)



3. Increase the level of difficulty to level 3. Can you score a goal? Draw a picture showing where the charges are placed to allow you to score a goal? Show the TA for bonus marks!  
(將難度提高到第三級，你可以得分嗎?畫出電荷要如何擺放才能射門得分?給助教看以便加分!)



4. What helped you to score the goals . How did the charged bodies affect the path ? How many charges did you use for the first difficulty level? What is the minimum number of charges you can use?  
(什麼東西幫助你得分。帶電粒子如何影響路徑?你需要用多少帶電粒子通過最簡單的難度?)

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#### 4. Charges and Fields Revisited 再探討電荷與電場

A 下載模擬器 Download, Run and Play with the PhET Simulation: "Charges and Fields".

In this exercise we will start to be quantitative, i.e. use numbers. Learn how to use all the different aids and measuring tools.

B Observe a Single +1nC charge.

- Place a +1nC charge on the screen. Check the boxes to show the electric field vectors, voltage and values.(在屏幕上放置 +1nC 電荷。點選方框以顯示電場向量、電壓和數值。)
- Do the electric field vectors point towards or away from the +1nC charge?  
(電場向量是指向還是遠離+1nC 電荷?)

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- Using the tape measure [m] and the sensor [V/m]. (a) Complete a table showing the change in electric field as you move further away from the charge. (b) Graph the relationship E vs r (c) Based on this data write a mathematical equation relating the decline in electric field to distance. [E(r)=???] Find the actual numerical value of the constant relating the electric field to distance.(使用捲尺[m]和感測器[V/m]。(a)填寫以下表格，顯示遠離電荷時電場的變化。(b) 畫出相關性 (c)根據數據寫出電場與距離的方程式。 [E(r)=???]找實際常數數值)

a. data			b. Graph E(r)	(b) Mathematical Relationship
Measurement	r Distance [cm]	E [V/m]		
1				
2				
3				
4				

- Make use of the Equipotential meter (on the right of the screen) to draw the equipotential lines. Draw a picture of the screen below showing the electric field vectors and the equipotential lines. 使用電位計(在屏幕右側)表在屏幕上繪製等位線。畫出所顯示出的電場向量與等位線。

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5. How does the direction of the equipotential lines relate to the direction of the electric field vectors (e.g. parallel, perpendicular...) 等位線與電場向量關聯(例如平行、垂直...)

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6. Use the tape measure [cm] along and the Equipotential meter. (a) Complete a table showing the change in electric potential as you move further away from the charge. (b) Graph (c) Based on this data write a mathematical equation relating the decline in electric potential to distance. [V(r)=] Find the actual numerical value of the constant.(使用捲尺[cm]和等電位計，(a)填寫以下表格，顯示遠離電荷時的變化。(c)根據數據寫出電位下降時與距離間相關公式。[V(r)=]找實際常數數值。)

a. data			b. Graph V(r)	c. Mathematical Relationship
Measurement	Distance r[cm]	Potential [V]		
1				
2				
3				
4				

**C Observe a Single -1nC (negative) charge.**

1. Reset the simulation. Place a -1nC charge on the screen. Check the boxes to show the electric field vectors, voltage and values.(重新模擬，在屏幕上放置 -1nC 電荷。點選方框以顯示電場向量、電壓和數值。)
2. Do the electric field vectors point towards or away from the -1nC charge? 電場向量是指向還是遠離-1nC 電荷?

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3. Using the sensor [V/m], what is the difference between the +1nC charge and the -1nC? 使用感測器 [V/m]，+ 1nC 和-1nC 差別為何?

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4. Make use of the Equipotential meter to draw the equipotential lines. How do the equipotential lines differ from those you drew in the previous section? 使用電位計表繪製等位線。請問與前一節繪製的等位線有何不同?

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**D Observe a Dipole (positive and negative charge).**

1. Making use of the tape measure, place two charges 40 cm apart on the screen. One should be negative and one should be positive. This is called a dipole. 使用捲尺量，分別放置兩個一正一負相距 40cm 的電荷。
2. Make use of the Equipotential meter to draw the equipotential lines on the screen. Draw a picture of the screen below showing the electric field vectors and the equipotential lines. 用電位計表在屏幕上繪製等位線。畫出螢幕上顯示電場向量和等位線的圖片。

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3. Describe the differences between the equipotential lines for a dipole (a plus and minus charge) and a single positive or negative charge? For example how does the electric field decrease with distance far from the dipoles?(描述偶極子(正負電荷)和單正電荷或負電荷等位線之間的差異?例如，當偶極子互相遠離，電場會如何隨距離遠離而降低?)


**E Observe and Analyze the Electric Field and Potential from a Line of Charges**

1. Place a line of at least 30 positive charges across the screen (near the top).  
(在屏幕上放置至少 30 個正電荷的線(靠近頂部)。)
2. Make use of the Equipotential meter to draw the equipotential lines on the screen. Draw a picture of the screen below showing the electric field vectors and the equipotential lines. 使用電位計表在螢幕上繪製等位線。畫出螢幕上所顯示的電場向量和等位線圖。



3. Using the tape measure [cm] along with the Equipotential meter and electric field sensor (a) Complete a table showing the change in electric potential and electric field strength as you move further away perpendicularly from center of the line of charges. Draw a graph to summarize your results. (使用捲尺[cm]與等位計和電場傳感器(a)填寫以下表格，顯示當你從電荷線中心垂直移開時，電位和電場強度的變化。)

a. data				b. Graph of E(r) and V(r)
Measurement	Distance r[cm]	Field E [V/m]	Potential [V]	
1				
2				
3				
4				

4. Based on your measured data, write mathematical equations relating the decline in electric field and electric potential to distance for a line of charges perpendicular to the midpoint between the two lines. [V(r)=] Find the actual numerical value of the constants. 根據測量數據，寫下(a)電場衰減和兩個電荷中點連線垂直的距離關係(b)電位與兩個電荷中點連線垂直的距離關係，[V(r)=] 找實際常數數值。

(a) Electric Field (V/m) -- E(r)	(b) Electric Potential (V) -- V(r)



## 5. 您的意見 Student Comments

A Did you enjoy the activity? 你喜歡這個活動嗎? Choose one”

LOVED 喜愛     75%     馬馬虎虎     25%     HATED 憎恨

Why? 為什麼?

B 提出 1 或 2 個問題 可以 添加到本題目簿 如果你的問題被使用, 加 1 分! (最多加 5 分) Suggest one or two additional questions that could be asked concerning any of the simulations you played with. (If we add your question, you will get 1% bonus marks for the course!)

Activity	Suggested Question	Answer to suggested question

C 有沒有別的意見? Any other suggestions to improve this activity?