

PBL: Introduction To Waves 波浪的遊戲

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Connected Website: <http://www.xiaotu.ca/tea/physics>

Group Names	IDs(3 digit)			Gr

1. Introduction 簡介

在這個單元，你要使用兩個有關波浪的模擬實驗，在你開始作答問題前，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 unit, you will perform virtual experiments with two different public domain physics simulations dealing with PBL: Introduction to Waves. Before you start answering the questions, play with each simulation. Get familiar with each of the different effects, buttons and tabs of the animations.

2. Mechanical Waves on a String

2.1 下載模擬器 Download, Run and Play with the PhET Simulation: "Waves on a String".

2.2 [Select: Oscillate] [選擇：振盪] Please find five different parameters will affect the wave characteristics. Draw a pictures to show the effect of changing each of these parameters individually. **(before and after)** 請找出 **5** 種參數能夠改變波型，並畫出前後圖差異。

	A English	b. Chinese	c. Picture before	d. Picture after
1				
2				
3				
4				
5				

2.3 Systematic Experimentation [Select: Oscillate, No damping, No end] [選擇：振盪, 無阻尼, 無邊界] Find the relationship between the λ and the frequency (**f**) 找出波長和頻率的關係

- Write down the results in the table. 將數值紀錄在下列圖表
- Draw a graph. 做出數線圖
- Fit the data to an equation. 從數線圖中得出式子

frequency (f)	λ (cm)	(b) graph	(c) Equation

- d. (i) Using the ruler and the timer, find the velocity (\bar{v}_{wave}) of the peak of the wave in the x-direction.
(ii) Does it depend on frequency? 使用尺和計時器找出波在 x 方向的速度 \bar{v}_{wave} ，並確認是否和頻率有關?

(i) —	(ii)
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- e. Compare your answer to part (d) with the equation you got in part (c). Comment on the result. 將 d 部分和 c 部分結合，寫出算式

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- 2.4 [Select: Oscillate] [選擇：振盪] Observe the wheel. Change the frequency(f) of the waves and record the angular velocity (ω) of the wheel? Record the Ratio. 注意車輪，寫下角速度 (ω) 與波的頻率(f)，並記錄兩者比例

波的頻率 frequency (f)	Angular Velocity (ω)	Ratio (ω/f)

- 2.5 [Select: Oscillate] [選擇：振盪] Look at the wheel. Write down why the wheel creates a sinusoidal wave. 注意輪子，寫下為何輪子的轉動可以使繩子變為 sin 波?

because the wheel rotate at y-direction and make the string oscillate 輪子旋轉時在 y 方向皆有正負之分，使繩子上下振動

3. Water Waves

- 3.1 下載模擬器 *Download, Run and Play with the PhET Simulation: "Wave: Interference"*
TAB: [Waves]

- 3.2 [Select: Water Icon] How does changing the frequency (f) of the drip (disturbance) affect the characteristics of the water waves? (i) What changes, (ii) What remains the same? 改變水滴的頻率會如何影響水波的特性? 特性哪裡改變了，甚麼特性還是一樣?

(i)	(ii)
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- 3.3 How does changing the amplitude (A) of the drip affect the characteristics of the waves? (i) What changes? (ii) what remains the same? 如何透過改變水滴的震幅來影響水波的特性? 特性哪裡改變了，甚麼特性還是一樣?

(i)	(ii)
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3.4 Sketch the water waves from both the top and side views. Label the distance between successive peaks and valleys as the wavelength (λ) of the wave in each of your sketches. Label the height of the wave as $2A$. 描繪水波的俯視圖及側面的剖面圖，並標出波峰和波谷之間距離在波長為 λ 時。標示出波的高度在 $2A$ 時。

Top	Side

3.5 Based on the experimental data, express mathematically how the wavelength (λ) of the wave depends upon its frequency (f)? How were you able to come to this conclusion? 根據實驗數據，波的波長為什麼取決於它的頻率？你要如何得到此結論(應該說如何證明)?

3.6 Come up with a method to determine the speed (v) of a water wave from the experimental data. (I) Outline your procedure. (ii) Share your results below. You should run several trials and average your results. 從實驗數據想出一個方法來確定水波的速度。列出方法的大綱，下面分享你的成果。可能要考慮做幾次試驗，平均結果。

(i)		

3.7 Change the frequency and amplitude of the drip?

a. How does changing the frequency (f) of the drip (disturbance) affect the speed (v) of the waves? 如何透過改變水滴的頻率影響波速?

b. What effect does changing the amplitude (A) of the drip have on the speed (v) of the waves? 改變水滴的震幅對波速有何影響?

3.8 How does amplitude (A) change with distance (r) from the drip (disturbance)? How could you tell? What might be causing this to happen? Can you suggest a mathematical equation to relate A to r i.e $A(r)$? 當水滴的距離改變會對震幅產生什麼影響? 如何去解釋? 導致這現象發生的主因為何?

4. Sound Waves

4.1 [Select:Sound Waves] Using the method you developed in the previous activity (§3.2e), (i) measure the speed of a sound wave. (ii) Compare this with the 'accepted' value of the speed of sound in the air ($c=343$ [m/s]). What might be some reasons for the discrepancies between your calculated value and the accepted value? 使用你在§3.2e 想出的方法，測量聲波的速度，請與音速的理論值比較，可能有什麼原因造成計算值和理論值之間的差異。

(i)	(ii)
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4.2 (i) How does the sound intensity (amplitude or 'volume') change as the separation (r) between the source and the observer increases? How could you tell? (ii) What might be causing this to happen? 當聲源和觀察者的距離增加，聲音強度（幅度或'體積'）如何變化？請解釋此現象，並找出可能發生的主因？

(i)	(ii)
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4.3 Compare the change in intensity with distance from source of the sound and water waves. (i) Which changes the fastest? (ii) Why? 比較聲波和水波的強度改變，哪一個改變的比較快？說出原因？

(i)	(ii)
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4.4 Turn the Audio on and listen to the waves. 改變波的振幅。Change the amplitude (A) of the waves. How does the volume of the sound change? If I double the amplitude of the waves, how does the volume you hear change? What does this tell you about your ears? 聲音的大小是如何改變的？如果我將振幅改為兩倍，聽起來會有何差異？耳朵有聽到何種改變？

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4.5 Turn the Audio on and listen to the waves. 改變波的振幅。Describe what happens as you change the frequency (f) of the waves leaving amplitude (A) constant. Do all frequencies of sound seem to have the same volume to you? 請敘述當改變頻率時的振幅改變。試問所有頻率的聲音聽起來音量大小都一樣嗎？

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5. Light Waves

5.1 [Select: Light Waves] Use the simulation to determine the wavelengths of the following colors of light. Fill in the table to the right. 使用模擬驗來定義各色光的波長範圍：

5.2 Using the methods you developed in the previous sections, (i) determine the speed (v) of a light wave. (ii) Does this speed depend on the frequency (colour) of light (f)? Amplitude (A)? (iii) Compare this with the 'accepted' value of the speed of light. What might be some reasons for any discrepancies between your calculated value and the accepted value? 使用你想出的方法定義光速。光的速度是否取決於它的頻率？震幅？請與光速的理論值做比較。可能有什麼原因造成計算值和理論值之間的差異？

(i)	(ii)	(iii)
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6. Slits & Interference – Tab [Slits]

6.1 Select [Water Waves] What do you think would happen to the waves if a barrier with a narrow slit (aperture) were placed in the path of the wave? (a) Draw your prediction as viewed from above (Top) in the space below. (b) Test your prediction by running the simulation. Comment on how closely your prediction matched what you observed. 你覺得當狹縫(光圈)放置在波傳遞的路徑上會發生什麼事?請以俯視圖畫出你預測圖形，測試你的預測並說明與實際理論有多接近?

(a) Top View Prediction	(b) Top View Actual

6.2 Select [Water Waves] What do you think would happen if you increased the size of the aperture? Would the waves diffract more or less? (a) Draw your prediction as viewed from above (Top) in the space below. (b) Test your prediction by running the simulation. 當波穿過一個大小合適的光圈，他們可以傳播或繞射出去。根據你的觀察，請你預測如果增加該孔徑的大小會發生什麼。請問波繞射有什麼改變?請在下面的空白處你預測的草圖。然後，測試你的預測和評論你觀察的結果

Top View Prediction	Top View Actual

6.3 Select [Light Waves]

- a. You saw that water waves can diffract when they interact with an appropriately-sized aperture. Light, being a wave, is capable of doing the same thing. Sketch what you predict the intensity pattern would look like on a screen placed in the path of a light wave : 在以前的模擬所看到波可繞射，當他們有一個大小合適的光圈進行交互。光是一個波，可以產生繞射。劃出你所預測在屏幕上所成的圖形。

Colour	顏色	Wavelength λ [nm]
Red	紅	
Orange	橙	
Yellow	黃	
Green	綠	
Blue	藍	
Violet	紫	

<p>光照射到屏幕上不通過光圈 Light Intensity vs Location on screen with no aperture</p>	<p>光照射到屏幕上經過一個單個寬縫 Light Intensity vs Location on screen with a single wide aperture (slit)</p>
<p>光照射到屏幕上經過一個單狹縫 Light Intensity vs Location with a single narrow aperture (slit)</p>	<p>光照射到屏幕上通過雙狹縫 Light Intensity vs Location with 2 closely-spaced narrow apertures (double slit):</p>

- b. Test your predictions. How closely do your predictions matched your observations? Fix as needed.
 c. Compare the width of the intensity distributions with the width of the slit. 測試你的預測，並解說你的預測結果跟你觀察到的現象有多接近。

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- d. The pattern of light formed after passing through a double-slit that resembles a series of closely-separated bands of light, and is known as an interference pattern. In the space below, predict (by drawing pictures and in words) what you think would happen to the interference pattern if the following parameters were adjusted independently: 你剛才看到的光通過雙狹縫後的圖案似一個系列條紋，被稱為干涉條紋。在下面的方框，預測（通過書寫或繪畫圖片），如果改變下列的參數，干涉條紋將會產生甚麼改變？

<p>改變光的波長 Wavelength of light (λ):</p>	<p>改變狹縫與屏幕的距離 Distance between slit and the screen (L):</p>
<p>改變狹縫的間距 Distance between slits (d):</p>	<p>改變狹縫的寬度 Light Intensity vs Location with a single wide aperture (slit)</p>

- e. Test your predictions. How closely do your predictions match your observation? 測試你的預測，並解說你的預測結果跟你觀察到的現象有多接近。 Modify your pictures accordingly.
 f. Using what you just observed, come up with three equations ($\Delta y = C * f(x)$) describing how the positions of the bright fringes (Δy , distance from the central maximum) depends on (i) λ , (ii) L, and (iii) d. 用你所觀察到的，請用三個關係式來描述明條紋的位置（Y - 從中央最大的距離）與 λ , L 和 d 的關係。請將三個關係式化簡為一個。

(i)	(ii)	(iii)
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g. Combine these 3 equations into 1 equation. Use the simulation to help you solve for the value of the arbitrary constant. What is the value of the constant in SI units? 請將三個關係式化簡為一個。請使用 SI 公制單位。

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6.4 Application: Use your new equation to solve the following problem: Light from a single source illuminates 2 narrow slits. The fringe spacing on a screen $L=1$ m behind the slits is $\Delta y=4.0$ mm. What is the spacing (in mm) between the two slits in the following cases? 用你新的方程式解下列問題，從鈉燈出來的光($\lambda = 589$ nm)經過雙狹縫，屏幕距狹縫 $L=1$ m，亮紋間距 $\Delta y=4.0$ mm，請問狹縫間距為何? **Should reverse the question. → given slit spacing what is the fringe spacing.**

a. Sodium lamp ($\lambda=589$ nm)	b. Red Diode . 改用紅光二極體雷射 ($\lambda=635$ nm)	c. HeCd laser 改用 HeCd 雷射 ($\lambda = 325$ nm)
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d. Predict what you will see if the slits in part (a) are illuminated with a white LED flashlight. Draw a picture 如果我在狹縫上用白光 LED 照射，請你預測將會呈現什麼圖形，並畫下來。

7. 您的意見 Student Comments

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

HATED 憎恨 25% 馬馬虎虎 75% LOVED 喜愛

Why? 為什麼？

7.2 对你的物理学理解有何帮助？ Was this activity helpful or your understanding of physics?

连一点没有帮助 No 一点帮助 馬馬虎虎 75% 是,帮助 Yes

7.3 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！ Suggest additional questions to ask concerning any of the simulations. (If your question is added, you get 1% bonus marks for the course!)

Activity	Suggested Question	Answer to suggested question