

PBL: Kinematics

活動單元：運動學

Prepared By
Janet Chen (陳衫豫), J D White (白小明)

Names	Student ID							Gr

0. Introduction 簡介

0.1 Preamble

在這個單元，你要處理四個運動學領域的模擬實驗，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 four different public domain physics simulations dealing with Motion. Before you start answering the questions, play with each simulation. Get familiar with both the English and Chinese versions. Learn each of the different effects and buttons of the animations. Where there are tabs, utilize them.

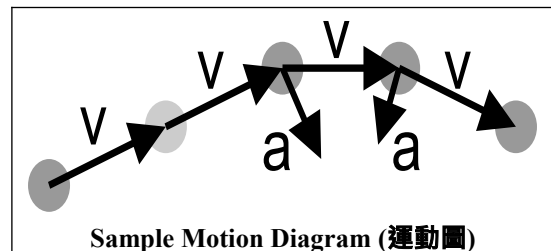
0.2 Notation

a. Key Terminology

1. $\underline{s}(t)$: position
2. $\underline{v}(t)$: velocity
3. $\underline{a}(t)$: acceleration
4. $|\underline{v}(t)|$: speed
5. Motion Diagrams (MD, 運動圖)

b. Key Skills

1. Drawing Motion Diagrams
2. Using a Spreadsheet to curve fit.

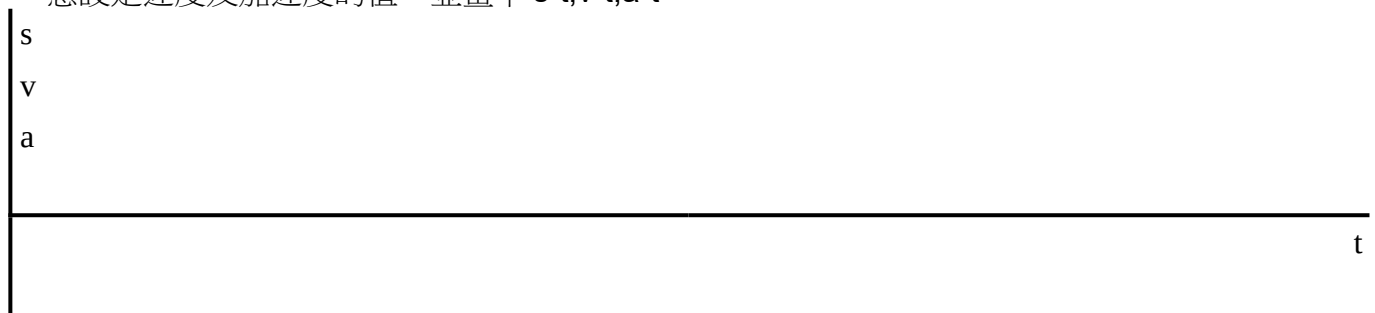


1. 1D Motion

1.1 下載模擬器 Download, Run and Play with the PhET Simulation: "Moving man"

1.2 Tab: [Introduction]. Turn on \underline{v} and \underline{a} vectors. Move the man. How do the velocity and acceleration vectors relate to each other? 移動畫面中的男人，並觀察加速度向量和速度向量之間的關係。

1.3 Tab: [Charts]. Enter a numerical value for $\underline{v}(0)$ and $\underline{a}(0)$. Run the simulation. Draw the $s=f(t)$, $v=f(t)$, and $a=f(t)$ graphs. Make sure you put a scale on the axis. 將頁面切到[圖表]，隨意設定速度及加速度的值，並畫下 $s-t, v-t, a-t$ 。



1.4 Comment on the relationship between the graphs (no math). 將你觀察到此三張圖表之間的關聯寫下。

1.5 Based on your graphs, write equations describing the motion (s, v, a) of the man. (Make sure you use the actual numbers from your graph.) 由上述的圖表寫下關於描述 s, v, a 的等式 (請使用上述觀察到的切確數字)

1.6 Generalize the equations to express the relationship between \bar{s} , \bar{v} , and \bar{a} 將上述寫下的式子用公式概括，公式的內容包含 \bar{s} , \bar{v} , \bar{a}

2. 2D Motion: General

2.1 下載模擬器 Download, Run and Play with the PhET Simulation: “Ladybug Motion 2D ”

2.2 Set: Vectors=Show both; Motion=Linear; Trace=Dots. Observe how the \bar{s} , \bar{v} , and \bar{a} behave. Record your observations with pictures. Observe the remote control window at the right bottom. 將運動狀態改為線性並觀察速度向量的反應，描述你觀察到的現象，也請注意右下角的控制視窗。

2.3 Choose acceleration (\bar{a}) in the remote control. What do you observe. How can an acceleration occur? What is the fundamental requirement for an object to accelerate. ? 再遙控視窗下選擇"加速度"在線性運動下觀察加速度在什麼情況下會出現，加速度的定義為何?

2.4 Set: Motion: Circular. Draw the motion diagram including \bar{v} and \bar{a} vectors. 狀態改為圓形，並將軌跡、速度、加速度在下方空白畫出來。

2.5 What is the relationship between the velocity vectors and acceleration vectors. 描述速度向量及加速度向量之間的關係。

2.6 Set Motion: Ellipse. Compare the ellipse motion and the circular motion in terms of position, velocity and acceleration. What is similar and what is different? 將狀態改為橢圓。觀察橢圓運動和圓周運動，並寫下相同處和相異處。

\vec{s}	
\vec{v}	
\vec{a}	

2.7 Set Motion: Manual. Drag the Ladybug with your mouse. Draw the motion diagram (remember to include \vec{a} and \vec{v}). Label the starting point A and end point B. 在選單中選擇一種運動狀態。用你的滑鼠拖動瓢蟲。以你開始的地方為 A 點，結束的地方為 B 點將瓢蟲經過的路徑畫在下方空白處。

2.8 In the above diagram, connect point A and point B with a straight line. What are the Scientific terms for the length of the straight line from A to B and the length of the route actually taken from A to B? 畫出一條直線連接 A 點和 B 點，這兩條線(直線、隨意畫的線)的物理定義名詞又是甚麼?

3. 2D Motion: Projectiles

3.1 下載模擬器 Download, Run and Play with the PhET Simulation: "Projectile motion".

3.2 Tab: [Intro] What angle should we use to launch the tank shell to reach the farthest distance (Answer using degrees (°))? How does the angle of firing influence the maximum distance of travel of the shell? What is the relationship? 砲彈能達到的距離中，最遠距離的射角是幾度?射角與砲彈距離的關係為何，請列出算式?(參考參數: v, θ, g)

3.3 Put a target at 20 meters from the cannon. Use a cannon ball to test the target. What initial conditions can be used to hit the target? 將目標放置離大砲 10m 遠，試發射砲彈，使砲彈命中的初始數值條件為何(高、砲彈重量、水平射程、角度、空氣阻力、球種及所花時間)?請記錄下來

3.4 Why does the y-component of velocity disappear at the highest point in the trajectory? 畫出最高點的力圖，並解釋為何鉛直速度為零。

Raise the initial height of the cannon to 10 meter. Modify the launch conditions to hit the target. Draw the **motion diagram**. 將大砲提高 10m，並嘗試打中目標，畫出運動圖分析

Make a projectile motion with only a horizontal initial velocity. What is the difference between full projectile and this one? What is the effect of initial vertical velocity? Explain using a motion diagram. 改變初始條件，將初始速度設為水平方向會跟原本的拋體運動有甚麼區別嗎？鉛直方向的速度對拋體運動造成甚麼效果？請利用力圖分析解釋。

3.5 Systematic Experimentation

- a. Perform an experiment to find the relationship between the distance of travel (x direction) of the shell and the angle of firing. (a) Record data at 5 different launch angles (b) Graph the travel distance (x direction) as a function of angle (c) Find an Equation to fit the graph. (You may make use of a spreadsheet to plot and then curve fit)

θ	x	(b) Graph	(c) Equation

- b. Perform an experiment to find the relationship between the distance of travel (x direction) of the shell and the initial speed $|\vec{v}|$ of the shell. (a) Record data at 5 different speeds (b) Graph the travel distance (x direction) as a function of launch speed (c) Find an Equation to fit the graph. (You may make use of a spreadsheet to plot and then curve fit)

$ \vec{v} $	x	(b) Graph	(c) Equation

- c. Perform an experiment to find the relationship between the distance of travel (x direction) of the shell and the mass of the shell. (a) Record data at 5 different masses (b) Graph the travel distance (x direction) as a function of mass (c) Find an Equation to fit the graph. (You may make use of a spreadsheet to plot and then curve fit)

m	x	(b) Graph	(c) Equation

3.6 Combine the results of the these 3 experiments into one equation, i.e. $x = f(\theta, |\bar{v}_{\text{launch}}|, m)$.

3.7 Explain projectile motion mathematically. Divide each component into its x and y components, including initial velocity. What is constant and what is changing? 利用公式解釋拋體運動，並把每個具有方向的物理量分成 x 方向跟 y 方向，包括初速度

4. 2D Motion: Rotation

4.1 下載模擬器 Download, Run and Play with the PhET Simulation: “Ladybug Revolution”.

4.2 Tab: [Intro]. Place bugs on $x=1$ and $x=3$. Spin the wheel. (a) Draw the \bar{v} and \bar{a} vectors at 3 different points in time. (b) What are the directions of the velocity and acceleration vectors? (c) What are the differences between the two bugs \bar{v} and \bar{a} ? (a)將兩隻蟲子個放在 $x=1$ 和 $x=3(m)$ 的位置，畫下加速度和速度向量。(b)速度和加速度的方向會指向哪? (c) 兩者的速度跟加速度有什麼不同

(a) Diagram	(b)
	(c) \bar{a}, \bar{v}

4.3 Tab: [Rotation] Set the angular velocity to 100 [1/s]. Draw graphs of the motion: $\theta(t)$, $\omega(t)$, $\alpha(t)$, $\bar{v}(t)$, $\bar{a}(t)$ and $s_x(t)$ and $s_y(t)$.

4.4 In the above question, what aspects of the variables (s, v, a) are constant? What aspects are changing? 讓瓢蟲旋轉。運動學中的參數 (s, v, a) 的哪幾項是常數? 哪些會發生變化(s, v, a)?

4.5 Consider the x and y positions. What is the mathematical function that can be used to describe these curves? Explain why it is that type of curve? 將角速度設為 100，畫出 x 和 y 的位置圖，並解釋為何為 sin 波。

4.6 Which parameter (θ , R or ω) is related to the maximum values of of the x,y position? x 和 y 的最大值取決於什麼? (θ , R, ω)

4.7 When the angular Velocity (ω =constant) is constant and Angular acceleration (α =0) is zero, why is the linear acceleration (\bar{a}) not zero? 當角速度為定值且角加速度為零時，為甚麼加速度不為零。

5. 2D Motion: Maze Challenge

5.1 下載模擬器 Download, Run and Play with the PhET Simulation: “Maze Game”

5.2 Move the Ball from the start to the Goal and record your fastest time, number of collisions, and final score at each level.

- Do it by controlling the “R” position.
- Do it by controlling the “V” velocity.
- Do it by controlling the “a” acceleration

Level	\bar{r} (Position)			\bar{v} (velocity)			\bar{a} (acceleration)		
	time (s)	collisions	score	time (s)	collisions	score	time (s)	collisions	score
practice									
Level 1									
Level 2									
Death									

5.3 In the above question, controlling which parameter was the easiest and which was hardest? Why?

6. Student Comments

6.1 你喜歡這個活動馬? Did you enjoy the activity? Choose one”

- HATED 憎恨 25% 馬馬虎虎 75% LOVED 喜愛

Why? 為什麼?

6.2 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

6.3 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! (最多加 5 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

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

--