

2021 年 澳門中學物理競賽

Concurso de Física para Alunos do
Ensino Secundário de Macau 2021

初級組

Elementar

學生証號碼：

Número do Cartão de Estudante _____

座位編號：

Número do Assento _____

競賽答卷注意事項

1. 使用藍色或黑色圓珠筆答題。若使用鉛筆和其他顏色筆答卷，可被視為白卷處理。
2. 將答題內容填寫在每一題下方框內。若空間不足，可使用每頁背面的方框繼續填寫。若空間再不足，可使用答卷最後補充頁上（第 17 至 18 頁）的方框繼續填寫，但需要標注填寫內容對應的題號。
3. 保持卷面整潔，適當使用草稿紙。卷面不可使用塗改工具。若必要，可用圓珠筆劃去已填下的不適用內容。
4. 本卷有概念題 5 題及計算題 5 題。概念題每題 10 分、計算題每題 20 分。卷面共 150 分。

Guidelines when answering the exam paper

1. Use blue or black pens to answer. If you use pencils or pens of other colors, those parts might be ignored and considered blank.
2. Fill in your answers within the bounding boxes under the questions. If the space is not enough, you can use the boxed spaces on the back. If that space is still not enough, you can use the boxed spaces on the supplementary pages (pp. 17 and 18) and supply the corresponding question number when you fill in the answers.
3. Keep the pages clean and use the provided scrap papers when needed. Do not use erasing or covering materials on the exam paper. If necessary, strike out the improper filled contents with cross lines.
4. There are 5 concept questions and 5 calculation questions. Each concept question is worth 10 points while each calculation question is worth 20 points. The total number of points counted in the exam is 150.

第一部分：概念題

PART I: Concept questions

1. 為什麼陀螺在旋轉時可以站立在其尖端上？當旋轉速度降低時，陀螺的旋轉軸會出現擺動。試解釋這種現象。

Why can a spinning top stand on its tip when it is spinning? When the spinning speed decreases, the axis of rotation would wobble around. Explain this phenomenon.

2. 用音叉的振動說明共振頻率的原理。哪些因素決定電路的諧振頻率？

Explain the principle of resonant frequency using the vibration of tuning forks. What factor determines the resonant frequency in an electric circuit?

3. 在存在空氣阻力的情況下，物體的哪些屬性決定自由下落運動中的終端速度？當一個乒乓球（ $\sim 3\text{g}$ ）和一個保齡球（ $\sim 10\text{ kg}$ ）從地面 1000 km 處自由落下時，哪個球將達到更高的極限速度？為什麼？

Which properties of an object determine the terminal speed during a free-falling motion in the presence of air resistance? When a ping-pong ball ($\sim 3\text{g}$) and a bowling ball ($\sim 10\text{ kg}$) fall freely from 1000 km above the ground, which ball is going to reach a higher terminal speed? Why?

4. 光如何在光纖內部長距離傳播？ 如何在不損壞光纖的情況下竊聽光纖中的信號？
How can light travel over a long distance inside an optical fiber? How can you eavesdrop the signal from an optical fiber without damaging the fiber?

5. 討論 3D 電影的工作原理。

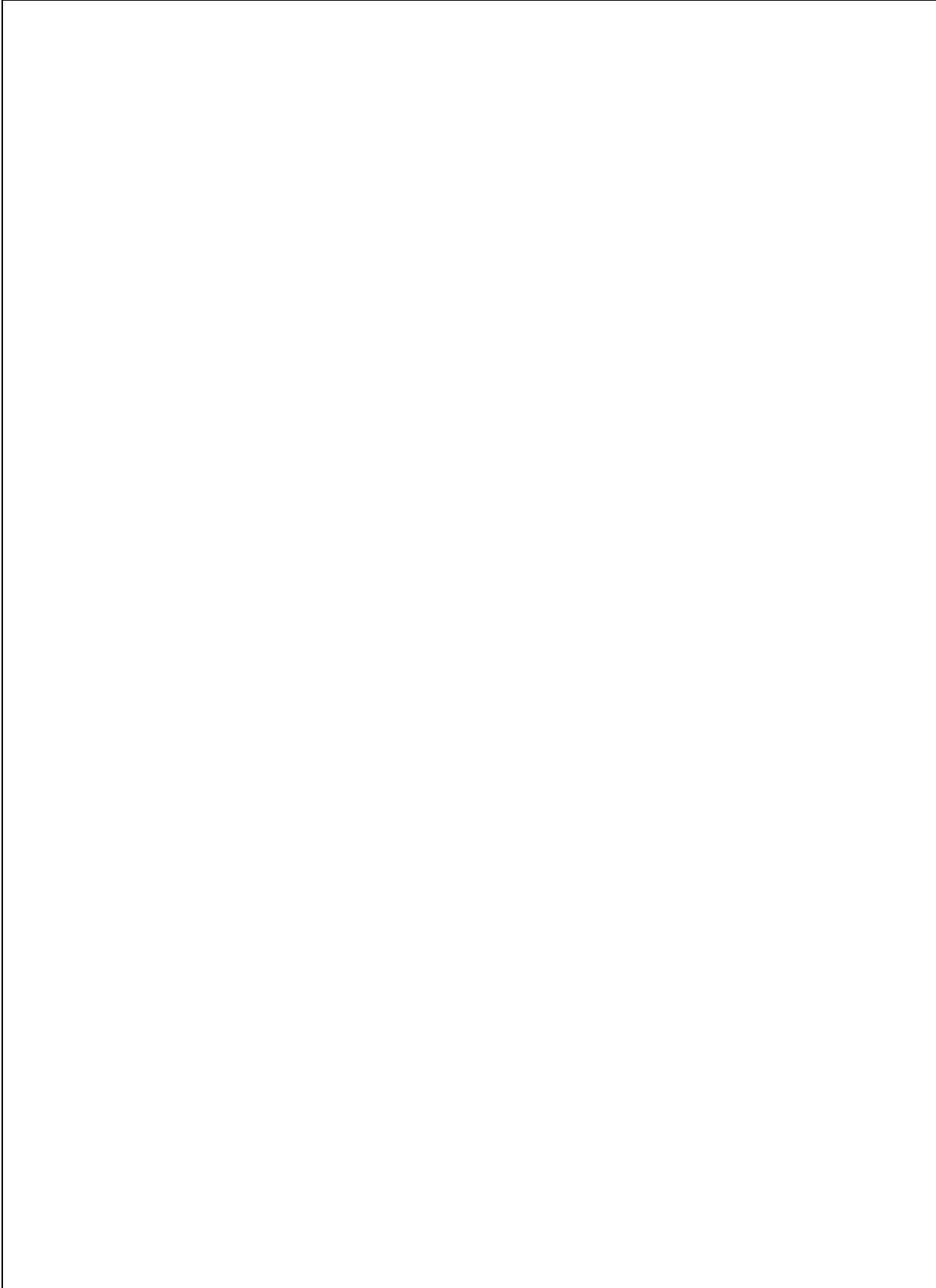
Discuss the working principle of 3-dimensional movies.

第二部分：計算題

PART II: Calculation questions

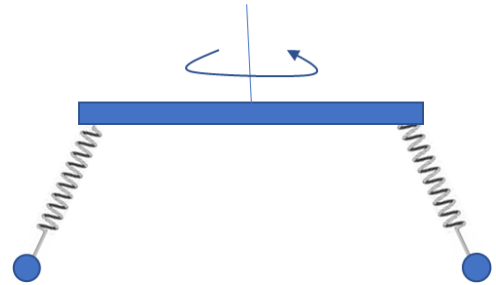
1. 一個靜止的球從高度 h 垂直落下, 並撞向相對於水平方向傾斜 45° 的坡道。碰撞為完美彈性碰撞, 因此球可以在坡道上反彈多次。計算(i) 第 1 次和第 2 次反彈之間的時間 t (ii) t 期間球行進的垂直距離(iii)第 2 次反彈中球擊中坡道時的速度 (iv) 在第二次和第三次反彈之間, 球行進的垂直距離。以 h 和重力加速度 g 表示答案。

A ball falls vertically from a height h from rest and hits a ramp which is inclined 45° to the horizontal. The ball then undergoes perfectly elastic collision and bounces multiple times on the ramp. Calculate (i) the time t between the 1st and 2nd bounces (ii) the vertical distance the ball travels during t (iii) the speed at which the ball hits the ramp during the 2nd bounce (iv) the vertical distance the ball travels in between the 2nd and 3rd bounces. Express your answers in terms of h and gravitational acceleration g .



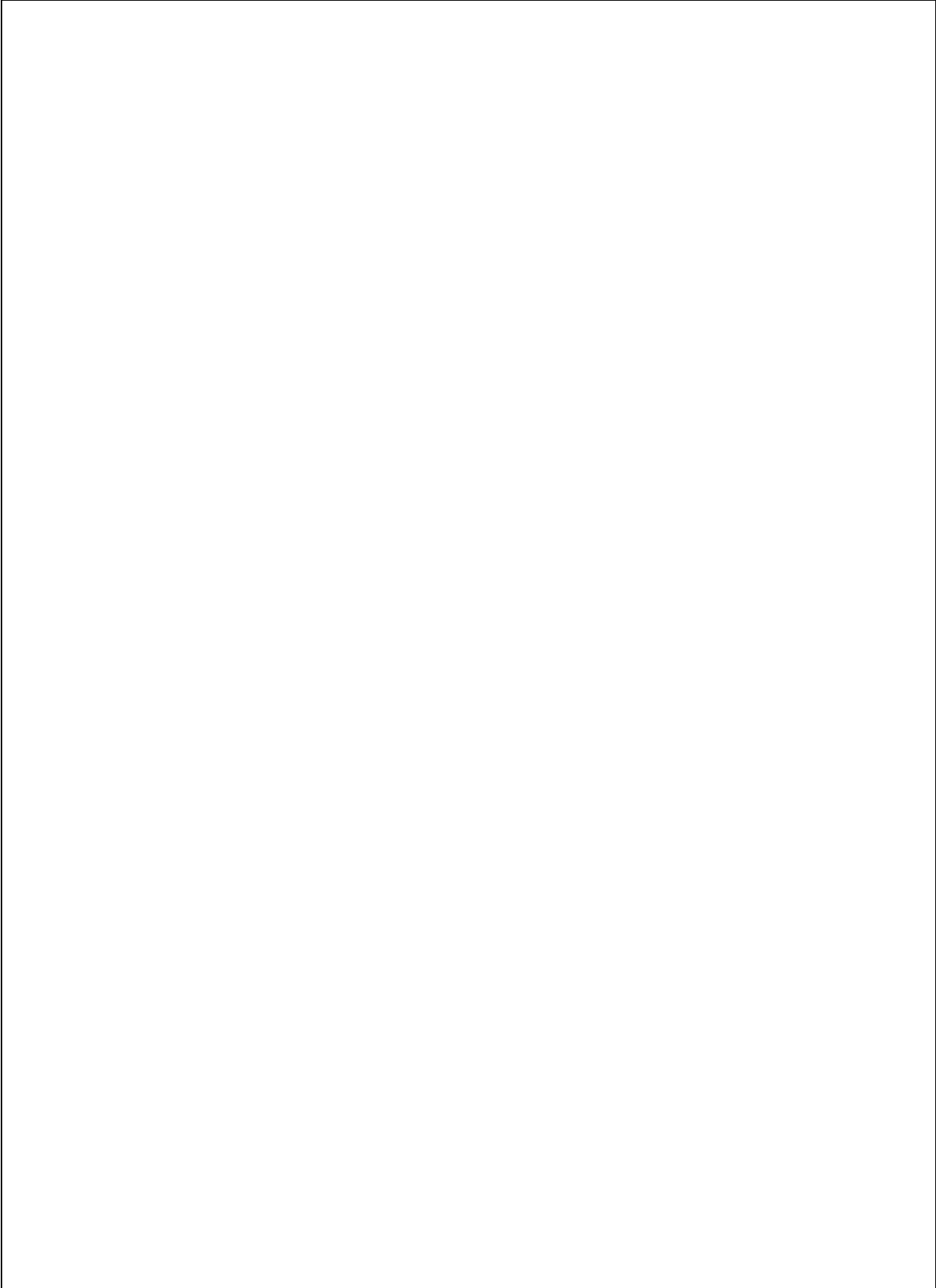
2.

一根長 10 m 的單槓在兩端各有一個質量可忽略不計的彈簧。在沒有任何負載的情況下，每個彈簧的自然長度為 1.8 m。現在，在每個彈簧的末端懸掛了一個重 100 克的小金屬球。當單槓開始繞其中心垂直軸旋轉，彈簧相對於垂直方向傾斜 30° ，並伸長至 2 米。求統旋的旋轉週期 T 。



如果轉速發生變化，使傾斜角度增加至 60° ，此時的彈簧長度是多少？

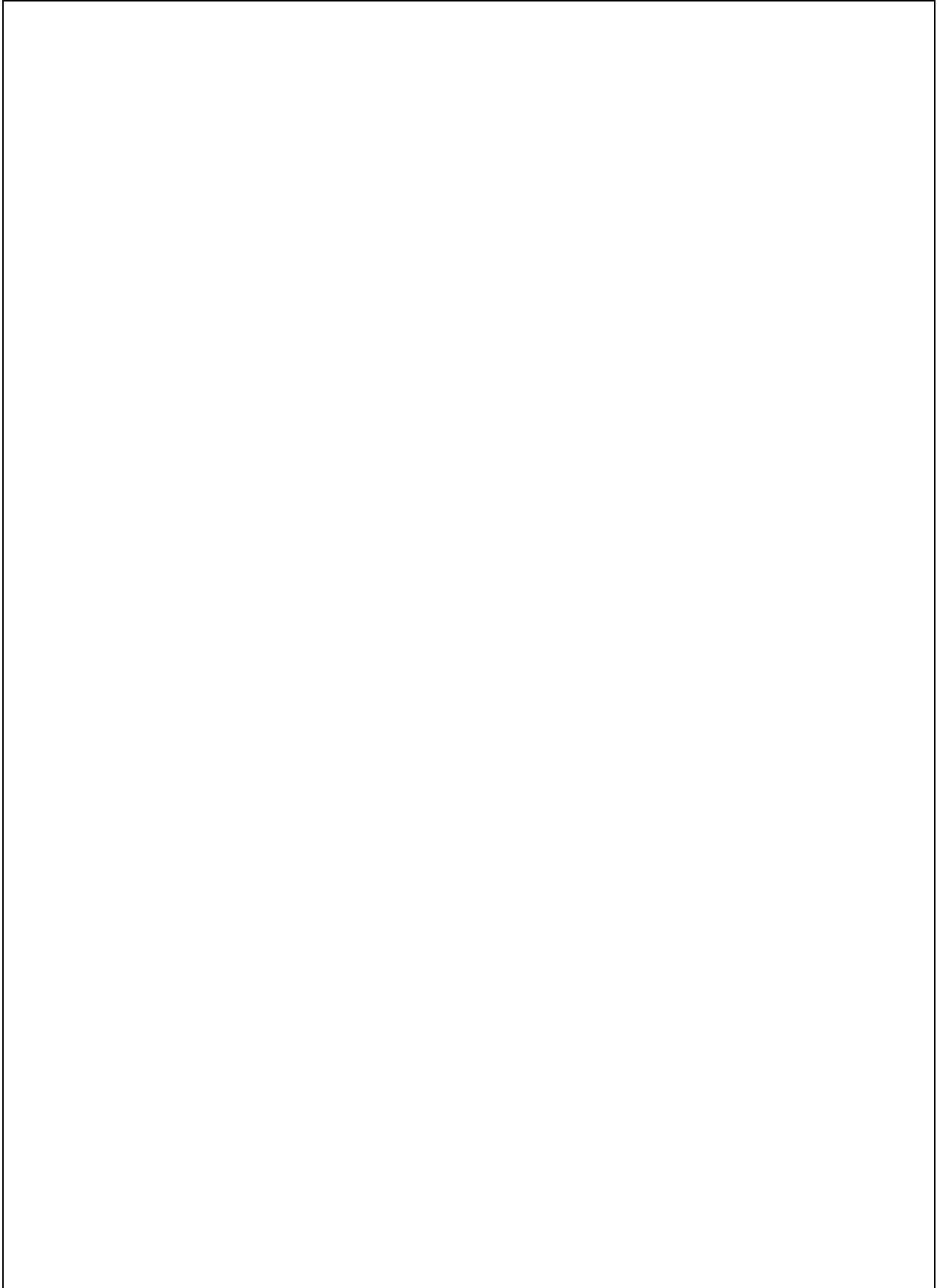
A horizontal bar, 10 m in length, has a spring with negligible mass attached at each end. Without any load, the natural length of each spring is 1.8 m. Now, a 100-gram small metal sphere is hanged at the end of each spring, and the bar is set into rotation about a vertical axis through its center. The springs are inclined at 30° to the vertical and the length of each spring becomes 2 meters. Determine the period T of rotation of the system. If the rotation speed changes such that the angle of inclination becomes 60° , what is the length of the springs?



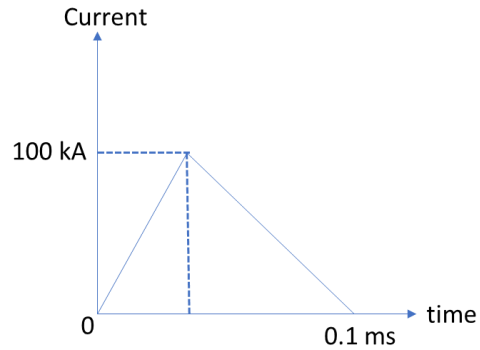
3. 將兩個相同的塑料球（質量分別為 5 g）充電至 +1.00 μC ，並通過兩條無質量的非導電線從固定點懸掛下來。 假設電線的長度為 1 m， 驗證電線之間的角度為 41° 。

（提示： 兩個電荷之間的靜電力 $F_E = \frac{1}{4\pi\epsilon_0} \frac{qQ}{d^2}$ ， $\epsilon_0 = 8.85 \times 10^{-12} \text{ F/m}$ ）

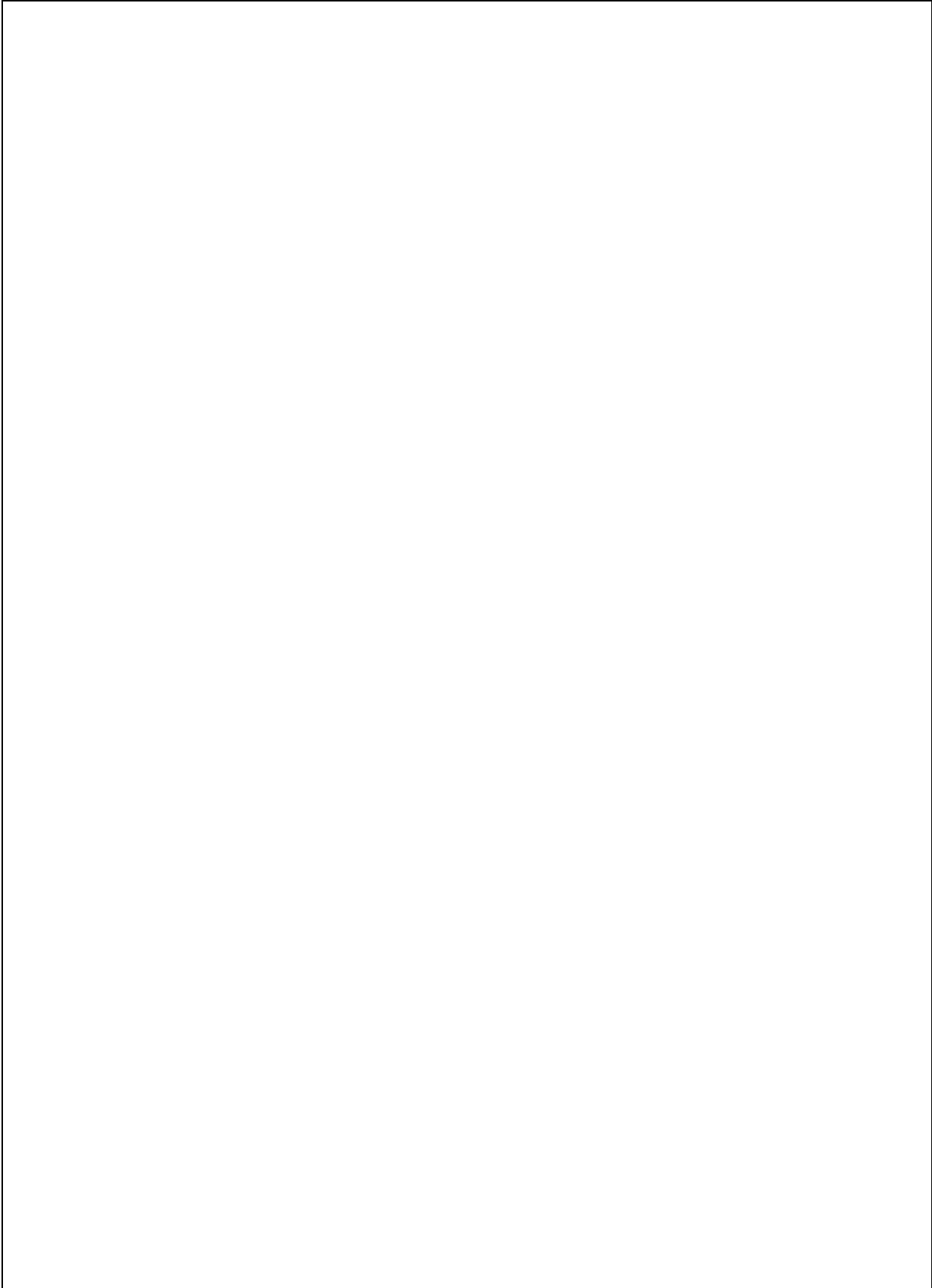
Two identical plastic balls, each of mass 5 g, are charged to +1.00 μC and suspended from a fixed point by two massless non-conducting threads. Assume that the length of each thread is 1 m. Verify that the angle between the threads is 41° . (Hint: the electrostatic force between two charges $F_E = \frac{1}{4\pi\epsilon_0} \frac{qQ}{d^2}$, where $\epsilon_0 = 8.85 \times 10^{-12} \text{ F/m}$)



4. 閃電是由雲層中累積的電荷引起，當電荷穿過空氣釋放到地面時，會產生電流脈衝。右圖是簡化模型，顯示了閃電時電流隨時間的變化。假設雲底與地面之間的距離 $h = 1 \text{ km}$ ，空氣的擊穿電場為 $E_o = 300 \text{ kV/m}$ 。(i) 一次雷擊釋放多少電荷？(ii) 平均電流是多少？(iii) 每次閃電釋放的能量是多少？

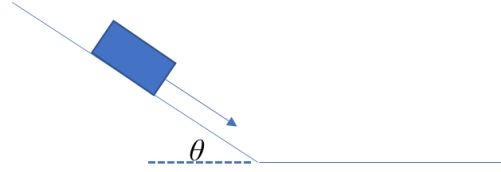


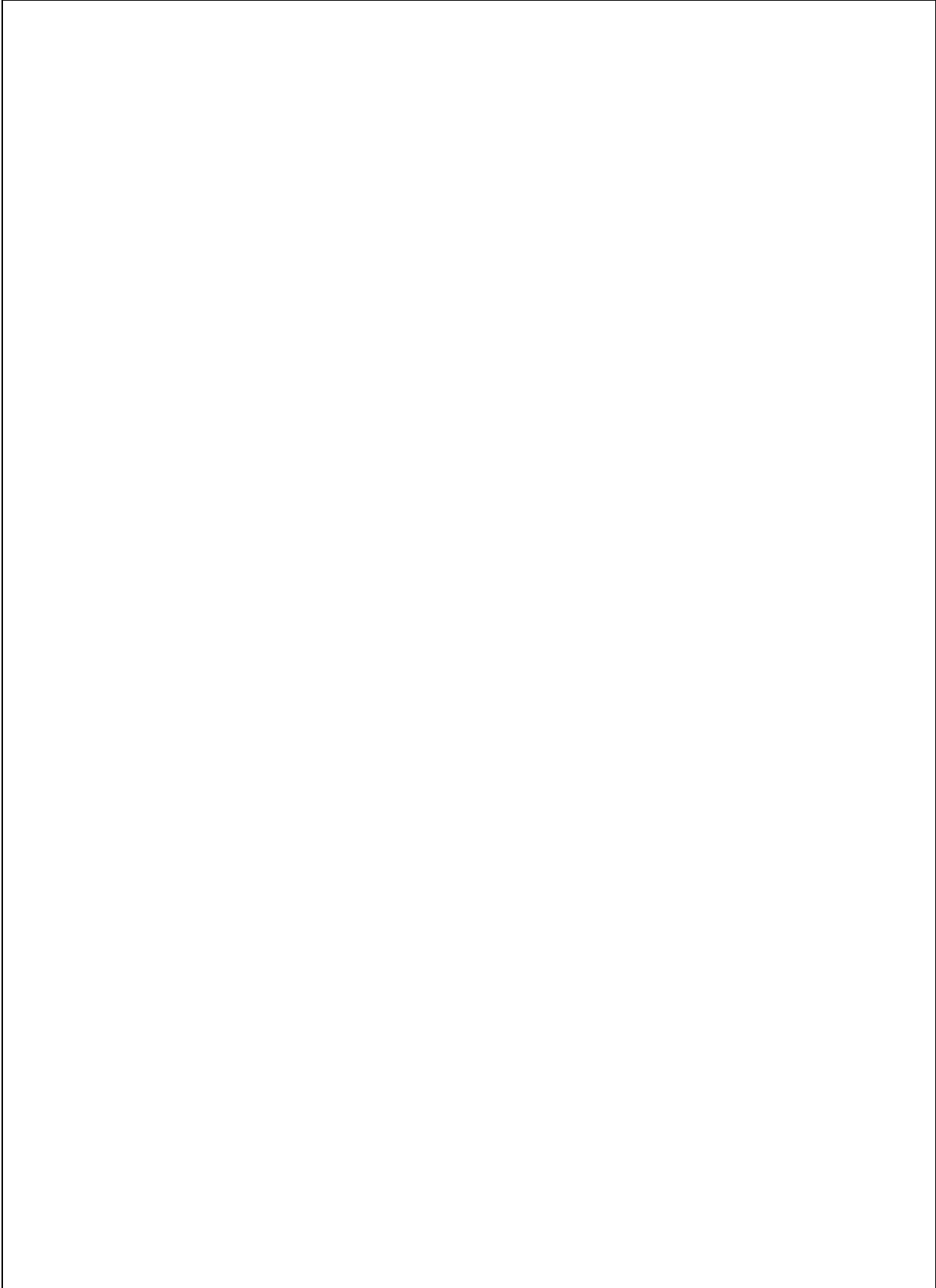
Lightning occurs when charges accumulating in the cloud discharge to the ground, resulting in a pulse of electric current flowing through air. The figure on the right is a simplified model illustrating the electric current as a function of time in a lightning event. Assume that the distance between the bottom of the cloud and the ground $h = 1 \text{ km}$ and the breakdown electric field of air is $E_o = 300 \text{ kV/m}$. (i) How much charge is released in one lightning event? (ii) What is the average current? (iii) What is the energy released during each lightning?



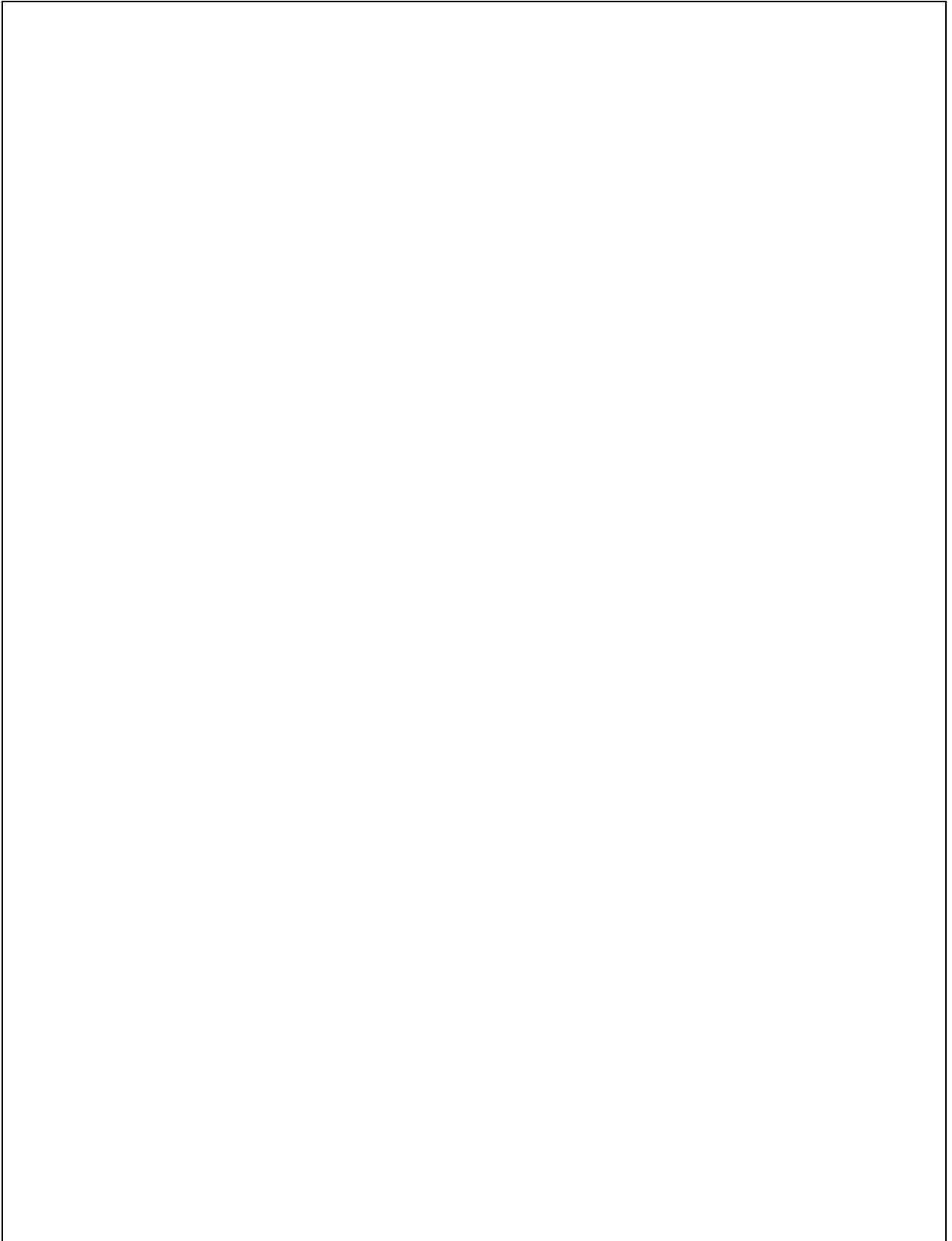
5. 質量為 m_I 的木塊被置於仰角為 θ 的斜面上, 並從靜止狀態向下滑動, 移動距離 d 後到達水平面。 假設在整個運動過程中動摩擦係數 μ_k 都相同, 求木塊移動的總距離。

A block of mass m_I is allowed to slide down from rest on an inclined plane with an elevation angle θ . The block moves over a distance d on the inclined plane and reaches a horizontal plane. Suppose that the dynamic frictional coefficient μ_k is the same throughout the entire course of motion, find the total distance traveled by the block.





補充頁 1



補充頁 2

