

2021 年 澳門中學物理競賽

Concurso de Física para Alunos do
Ensino Secundário de Macau 2021

高級組

Avançada

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. 簡述放射性碳定年法的工作原理。

Briefly explain the working principles behind radiocarbon dating.

2. 卡諾熱機的循環由哪幾個過程組成？請簡單解釋。

What does a Carnot heat engine cycle consist of? Briefly explain.

3. 試解釋相對論裏類時矢量與類空矢量的區別。

Briefly explain the difference between timelike vectors and spacelike vector in the special theory of relativity.

4. 假設我們有某一金屬原材料，其質量為 m ，能加工成任意的圓柱狀。考慮將這一圓柱體一端固定，另一端垂向地面，形成一簡易單擺。那麼怎麼設計才能將單擺的週期儘量延長？試簡單解釋。

Suppose we have some raw metallic materials, the mass of which is m , and we can cast it into any cylindrical shape. Consider that one end of the casted cylinder be fixed and the other end hanged down towards the ground to form a simple pendulum. Then how should we design the pendulum to make its period as long as possible? Explain briefly.

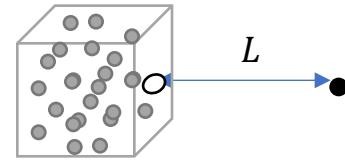
5. 一簡單 RL 充電電路（一個電阻、一個電感和一個乾電池串聯）原為打開狀態，電感裏無磁場。那麼在電路閉合的那一瞬間，電路裏電流達到最大值、最小值還是其他值？試簡單解釋。

A simple RL charging circuit (a resistor, an inductor, and a battery connected in series) is originally open, where the inductor has no magnetic field. At the moment the circuit is closed, does that current reach a maximum, a minimum, or something else? Explain briefly.

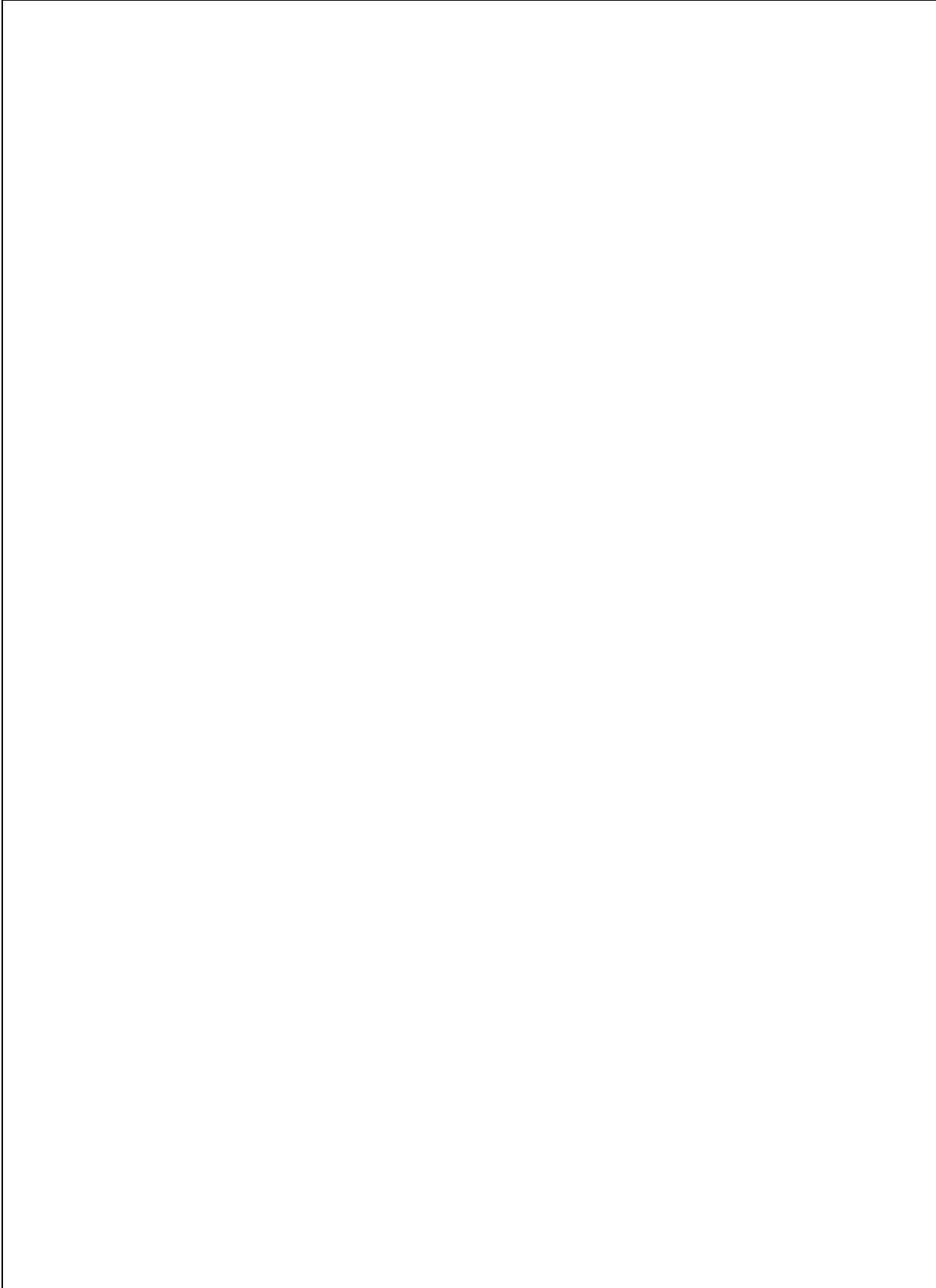
第二部分：計算題

PART II: Calculation questions

1. 考慮一裝有某種原子的立方盒背加熱到溫度 T 。立方盒的一側面上開有一直徑為 D 的小圓孔（ D 的直徑與原子尺度相當），形成一原子束。假如原子質量為 m ，原子束離小孔距離 L 時的寬度為多少？參考附圖。

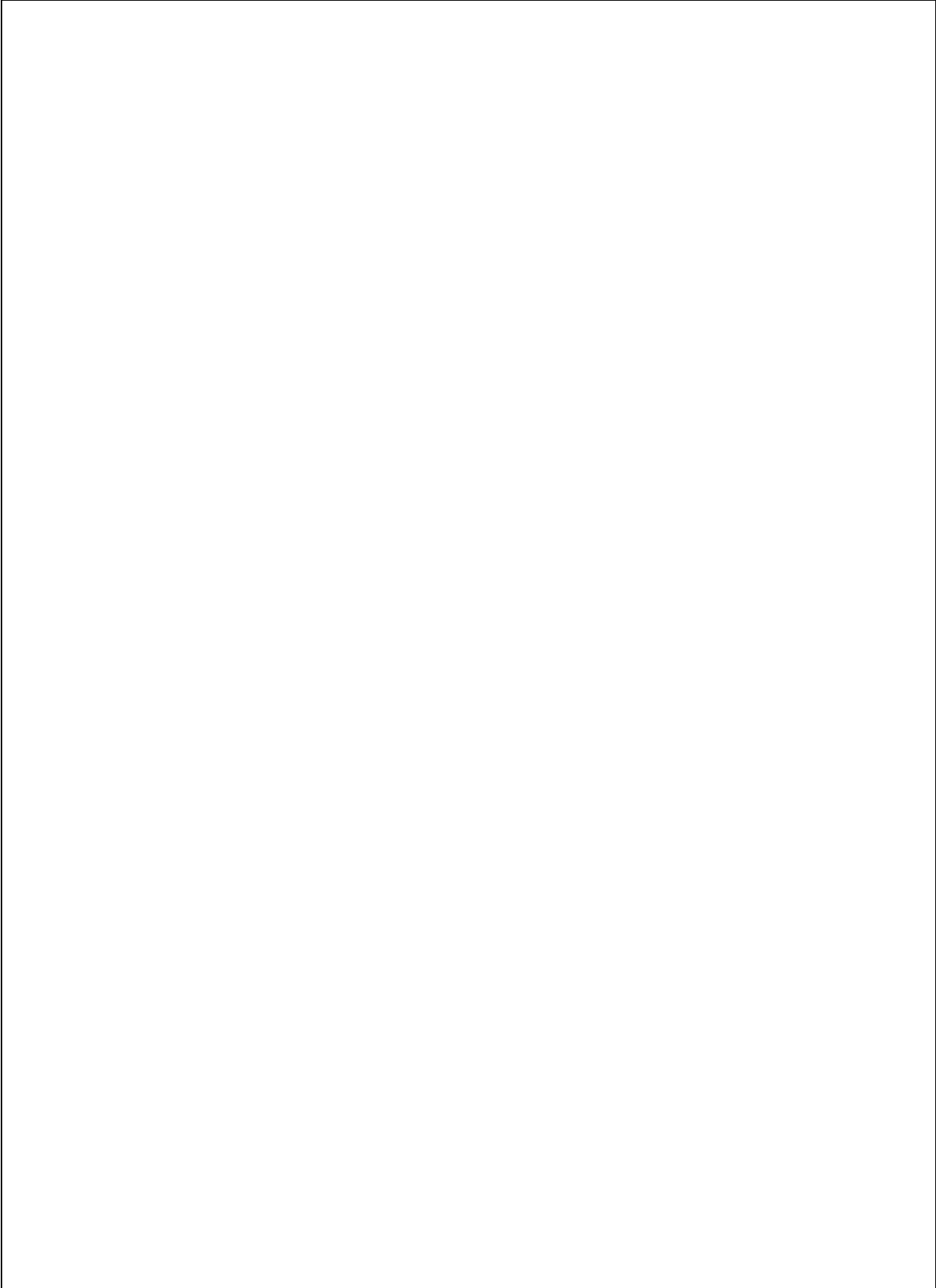


Consider that a cubic box containing atoms of some certain type is heated up to a temperature T . One side of the box is opened with a circular hole of diameter D (D is similar to the scale of the particles), forming an atomic beam. If the atomic mass is m , what is width of the atomic beam at a distance of L away from the hole? See the picture for reference.

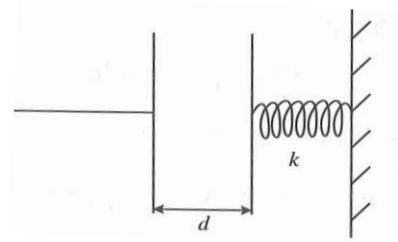


2. 考慮兩個質量分別為 m_1 和 m_2 的方塊被放置在一個傾斜角為 θ 的斜坡上，以一被拉緊的細線相連，其中 $m_1 > m_2$ ，並且 m_1 在斜坡的較上方位置。兩方塊在斜坡上有不同的靜摩擦係數，分別為 μ_1 和 μ_2 。(a) 線上的張力為多少？(b) 若系統從靜止啓動，行進距離 L 需多長時間？

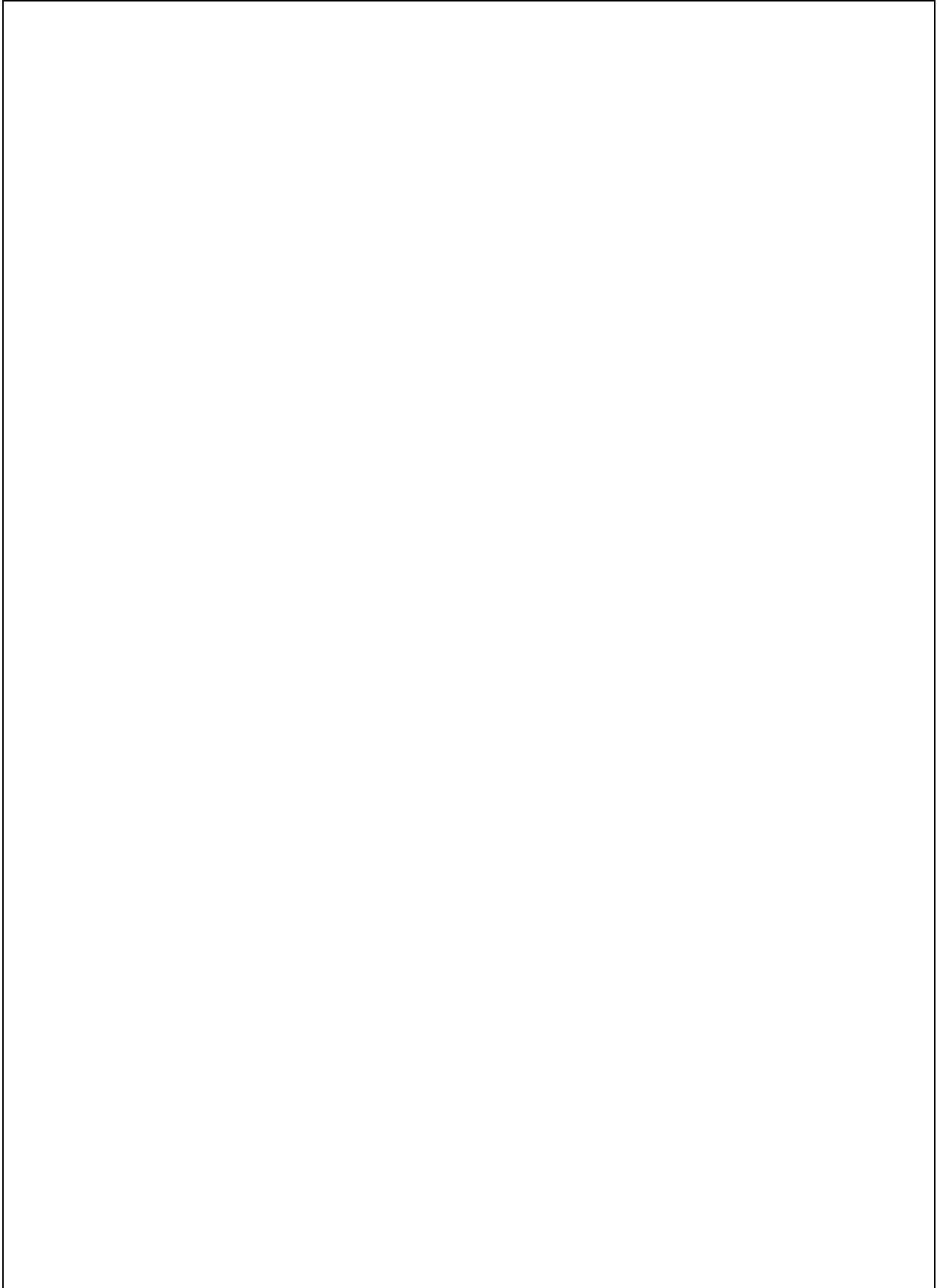
Consider two blocks, respectively of masses m_1 and m_2 , placed on a slope of tilting angle θ and connected by a taut string, where $m_1 > m_2$ and m_1 is at a higher position on the slope. They experience different static frictional coefficients μ_1 and μ_2 , respectively. (a) what is the tension on the string? (b) If the system starts moving from rest, how long does it take to travel a distance L ?



3. 如圖所示，有兩相同、面積為 A 、分別充電至電荷 Q 與 $-Q$ 的平行電板，被放到一起，兩板間距為 d ($d \ll A$)。現在右電板通過一常數為 k 的彈簧連接到牆上，其位置由靜電力與彈簧力的平衡達到一新的位置。(a) 右電板離原位置的位移是多少？
(b) 現在電容為多少？

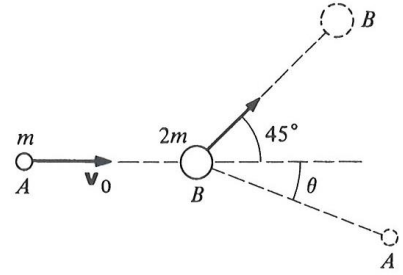


Consider that two identical parallel plates of plate area A are charged to charges Q and $-Q$, respectively, and brought together at a separation d ($d \ll A$), as shown in the figure. The right plate is now attached to the wall through a spring of constant k , reaching a new position due to the equilibrium between the electrostatic force and the spring force. (a) What is the displacement of the right plate from the original position? (b) What is the capacitance?

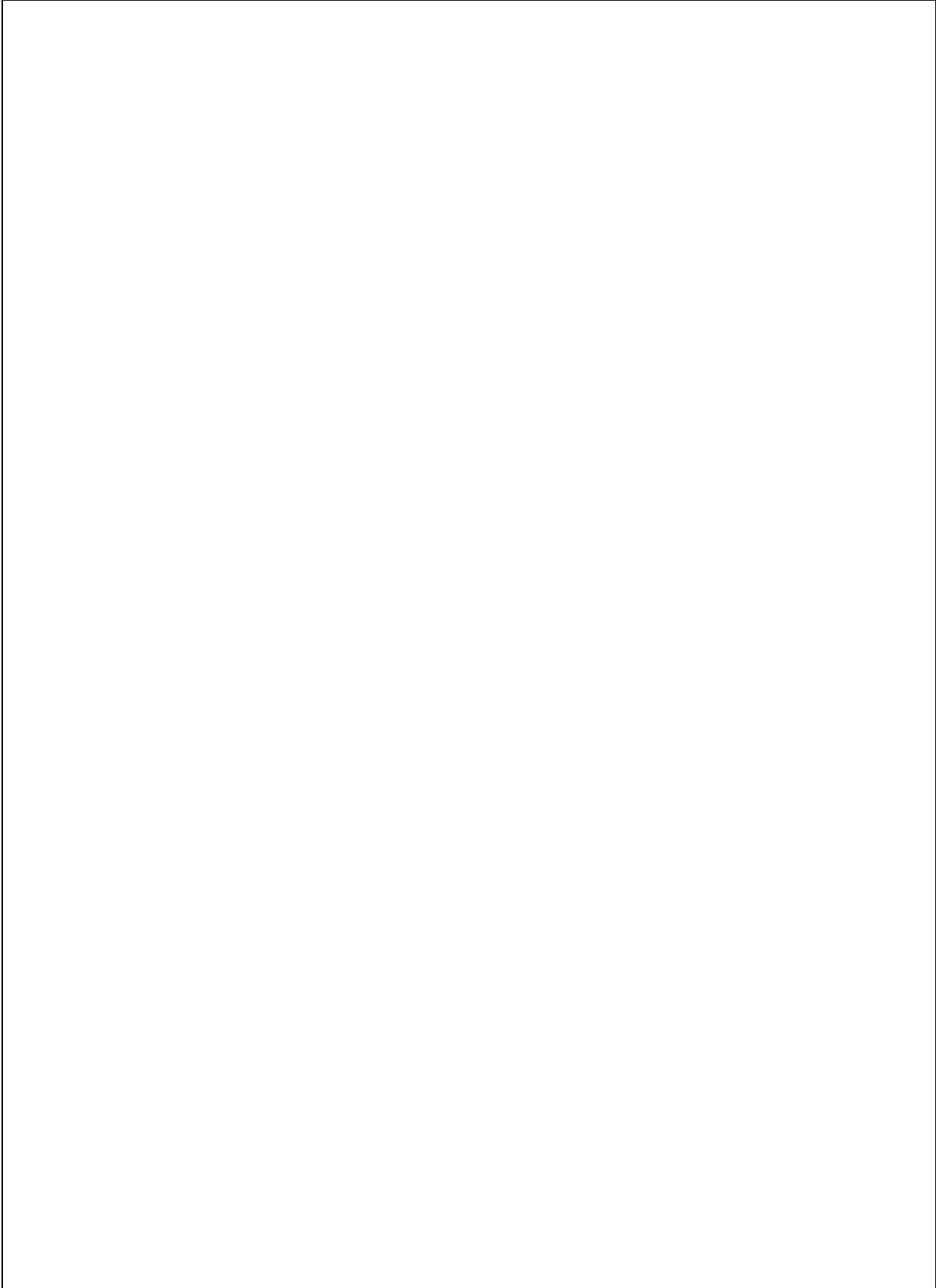


4. 粒子 A 的質量為 m ，初速度為 v_0 。其與質量為 $2m$ ，初始靜止的粒子 B 碰撞，形成如圖中所示的路徑。碰撞後，角度 θ 為多少？

Particle A of mass m has initial velocity v_0 . After colliding with particle B of mass $2m$ initially at rest, the particles follow the paths shown in the figure. What is the angle θ after the collision?

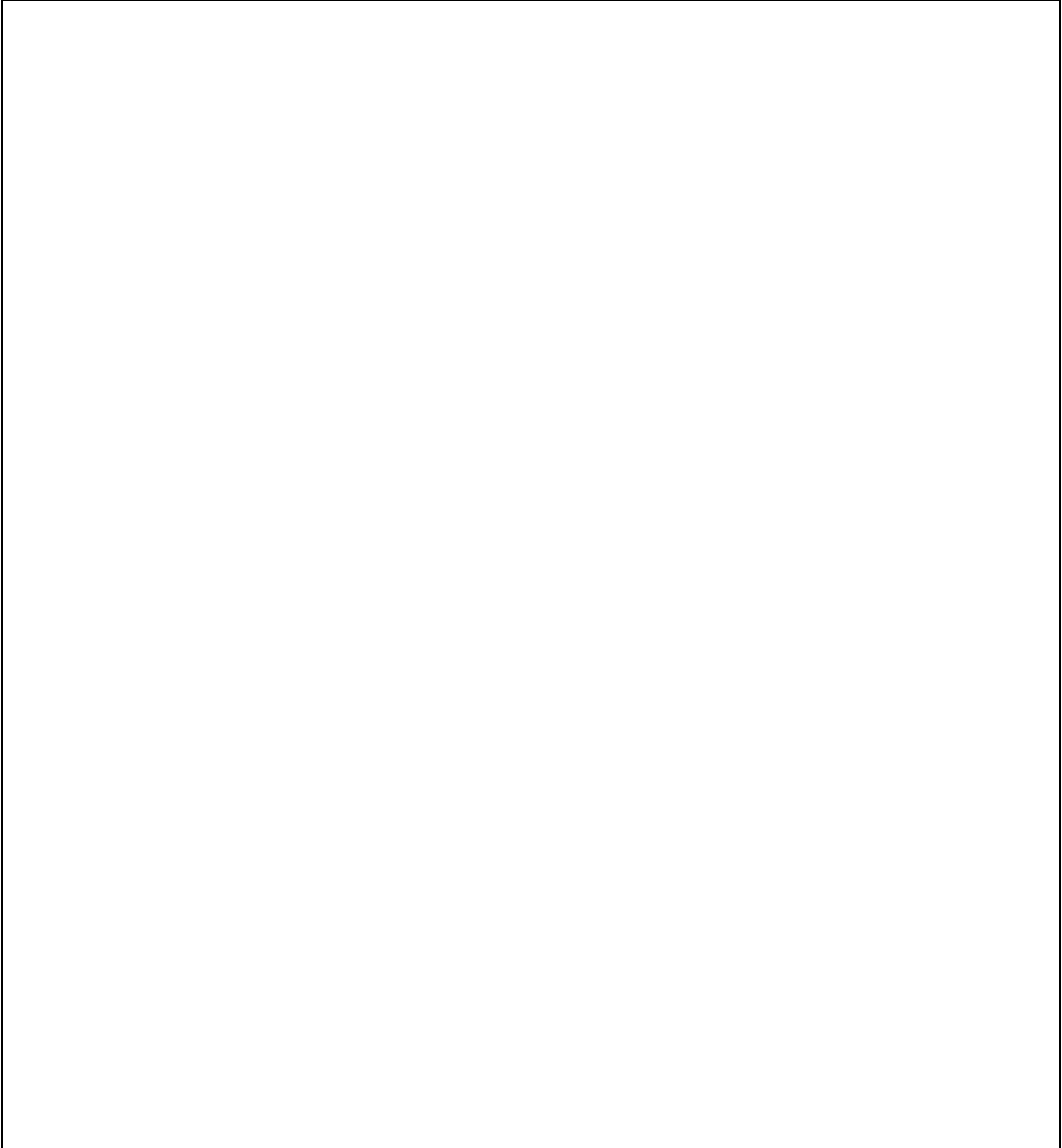
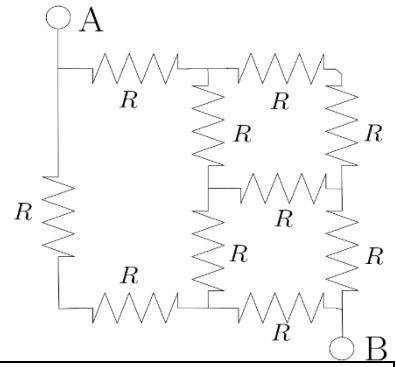


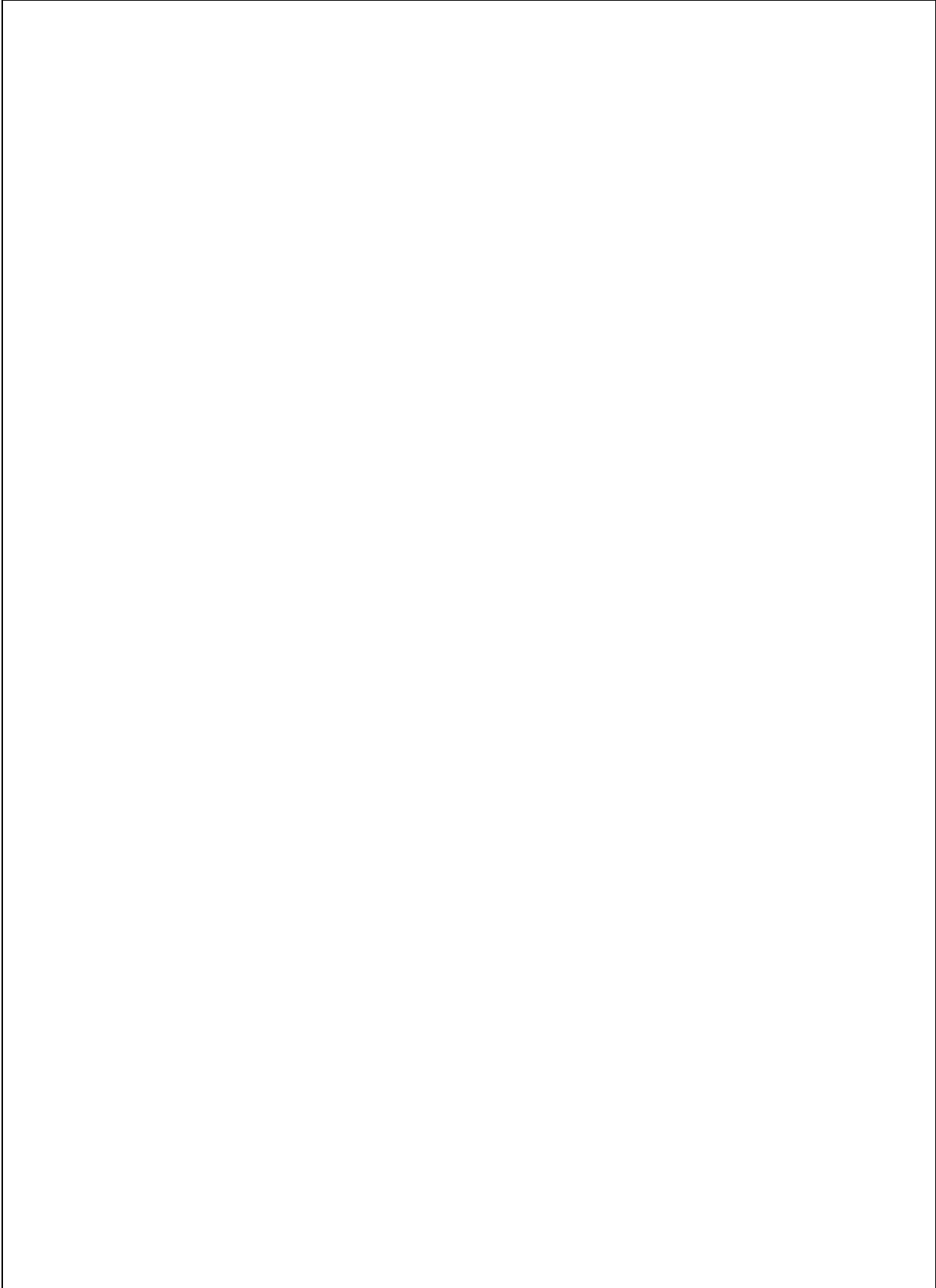
A large empty rectangular box provided for the student to write their solution to the problem.



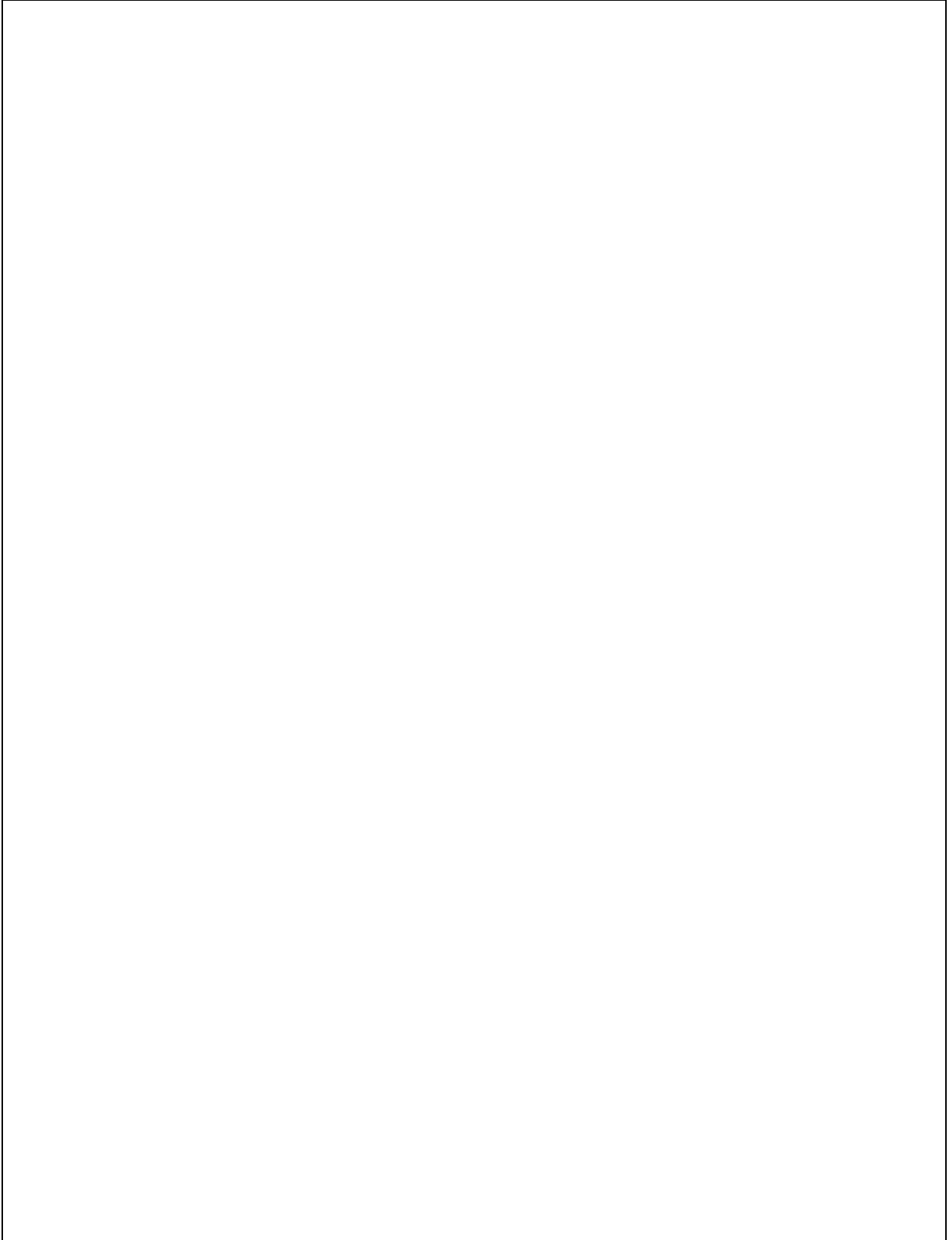
5. 假定圖中每個電阻的阻值皆為 R ，那麼節點 A 與節點 B 之間的等效電阻是多少？

What is the equivalent resistance between node A and node B in the figure, given each resistor having resistance R ?





補充頁 1



補充頁 2

