

2022/2023 學年 學界物理比賽

Concurso Interescolar de Física do  
ano lectivo de 2022/2023

高級組

Avançada

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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 4 題及計算題 4 題。概念題每題 10 分、計算題每題 20 分。卷面共 120 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 4 concept questions and 4 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 120.

第一部分：概念題

PART I: Concept questions

1. 黑體輻射的概念與什麼有關？試述它的研究對象並簡述普朗克的研究理論。不必陳述特定方程來回答。

What does the concept of blackbody radiation concern about? State its subject of study and briefly about Planck's theory about it. Formulae are not necessary for the answer.

2. 一個單質氣體，例如氫氣，所發出的光譜與太陽光譜有什麼不一樣？其特點代表了氣體的哪些物理結構？試簡述。

What is difference between the spectrum emitted by single-element gases, such as hydrogen, and the spectrum of the Sun? What do the features imply about the physical structure of these gases? Briefly explain.

3. 簡述 AC-AC 變壓器（譬如將 380V 變壓成 220V 或 110V 變壓成 220V）的物理結構和其工作原理。

**Briefly state the physical structure and the working mechanism of an AC-AC electrical transformer (such as those transforming 380V down to 220V and 110V up to 220V).**

4. 高性能跑車或賽車經常利用鋁合金或鎂合金來打造車輪，並利用大幅度鏤空的車輪設計。這是為什麼？試從力學角度解釋。

High performance sports cars or racing cars very often have aluminum alloy or magnesium alloy wheel rims of large-scale hollow designs. Why is that? Briefly explain from a mechanics perspective.

第二部分：計算題

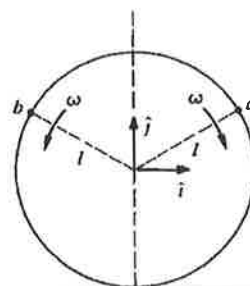
PART II: Calculation questions

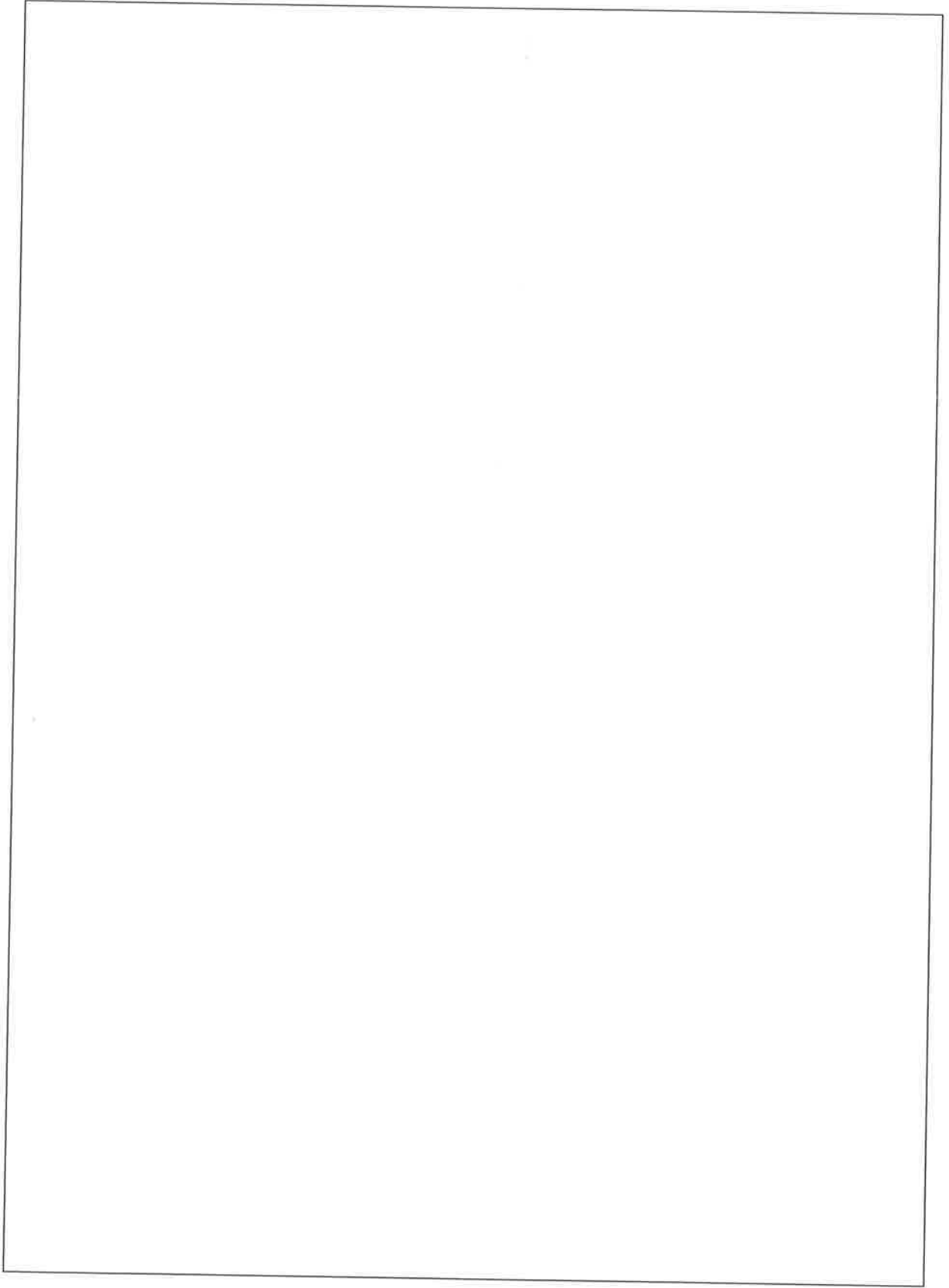
1. (a) 假設一質點相對坐標系A的相對速度是 $v_A$ 。那麼相對與坐標系A平移距離 $\vec{R}$ 的坐標系B，該質點的相對速度為何？

A point is observed to have velocity  $v_A$  relative to coordinate system A. What is its velocity relative to coordinate system B, which is displaced from system A by distance  $\vec{R}$ ?

- (b) 參考插圖，質點a和b以角速率 $\omega$ 沿圓周相反方向移動。在 $t = 0$ 時刻，兩質點皆在坐標位置  $\vec{r} = l\hat{j}$ ， $l$ 為圓半徑。找出a質點相對b質點的速度。

Referring to the figure, particles  $a$  and  $b$  move in opposite directions around a circle with angular speed  $\omega$ . At  $t = 0$ , they are both at the point of coordinate vector  $\vec{r} = l\hat{j}$  where  $l$  is the circle radius. Find the velocity of  $a$  relative to  $b$ .



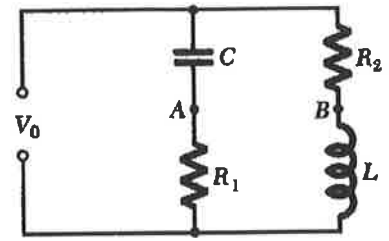




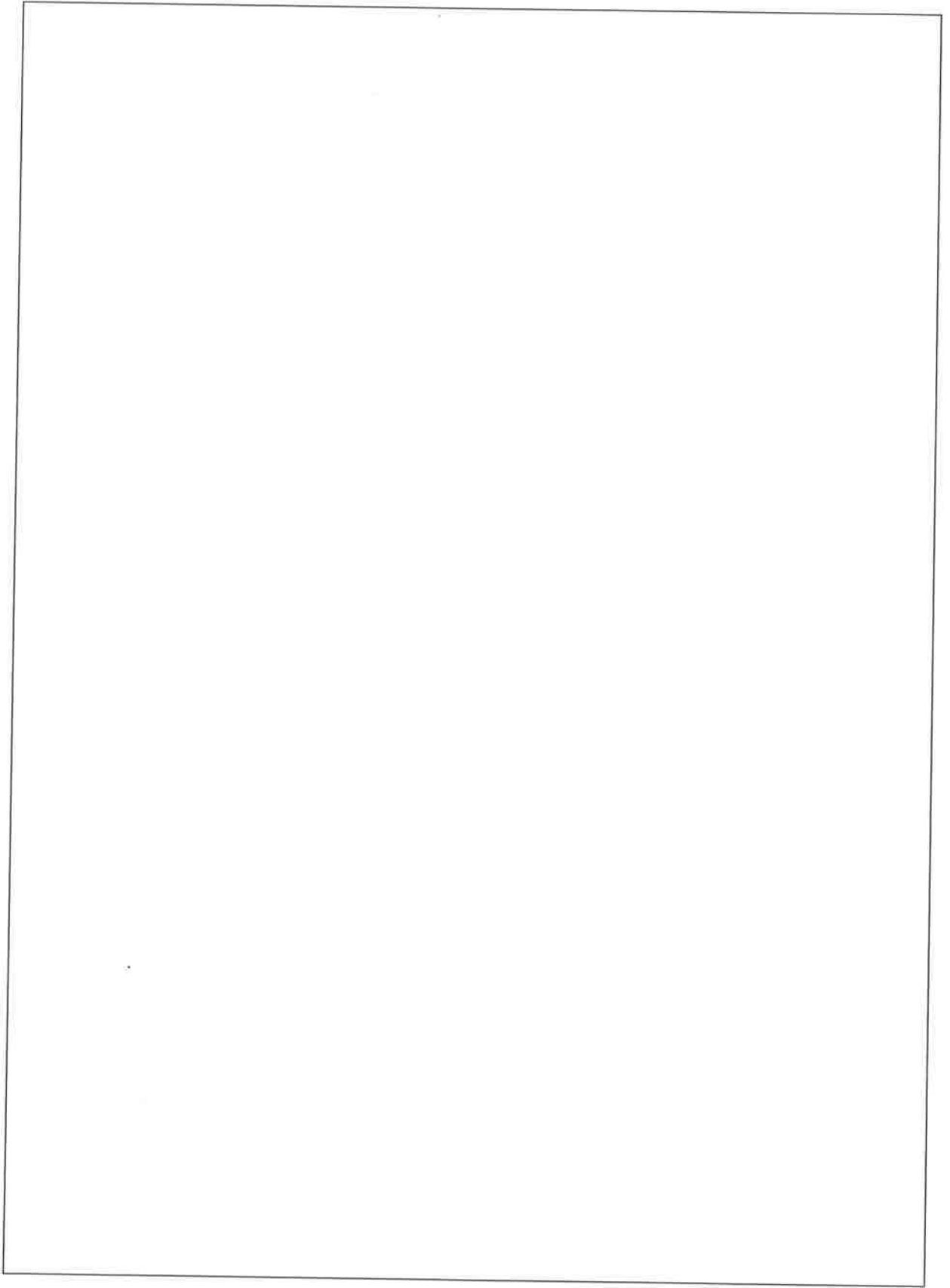
2. (a) 如圖所示，當開電路端連接一波幅 $V_0$ 、頻率 $\omega$ 的 AC 電壓源時，節點 $A$ 和 $B$ 間的壓差 $V_{AB}$ 是多少？

Shown in the figure, if an AC voltage source of amplitude  $V_0$  and frequency  $\omega$  is applied at the open-circuit end, what is the voltage drop  $V_{AB}$  across node  $A$  and node  $B$ ?

- (b) 如何基於此電路構造一個簡單的 AC 電橋來測量電感？  
How can one construct a simple AC bridge for inductance measurement based on this circuit?

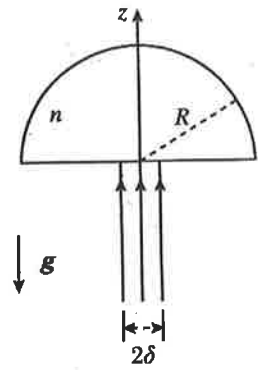


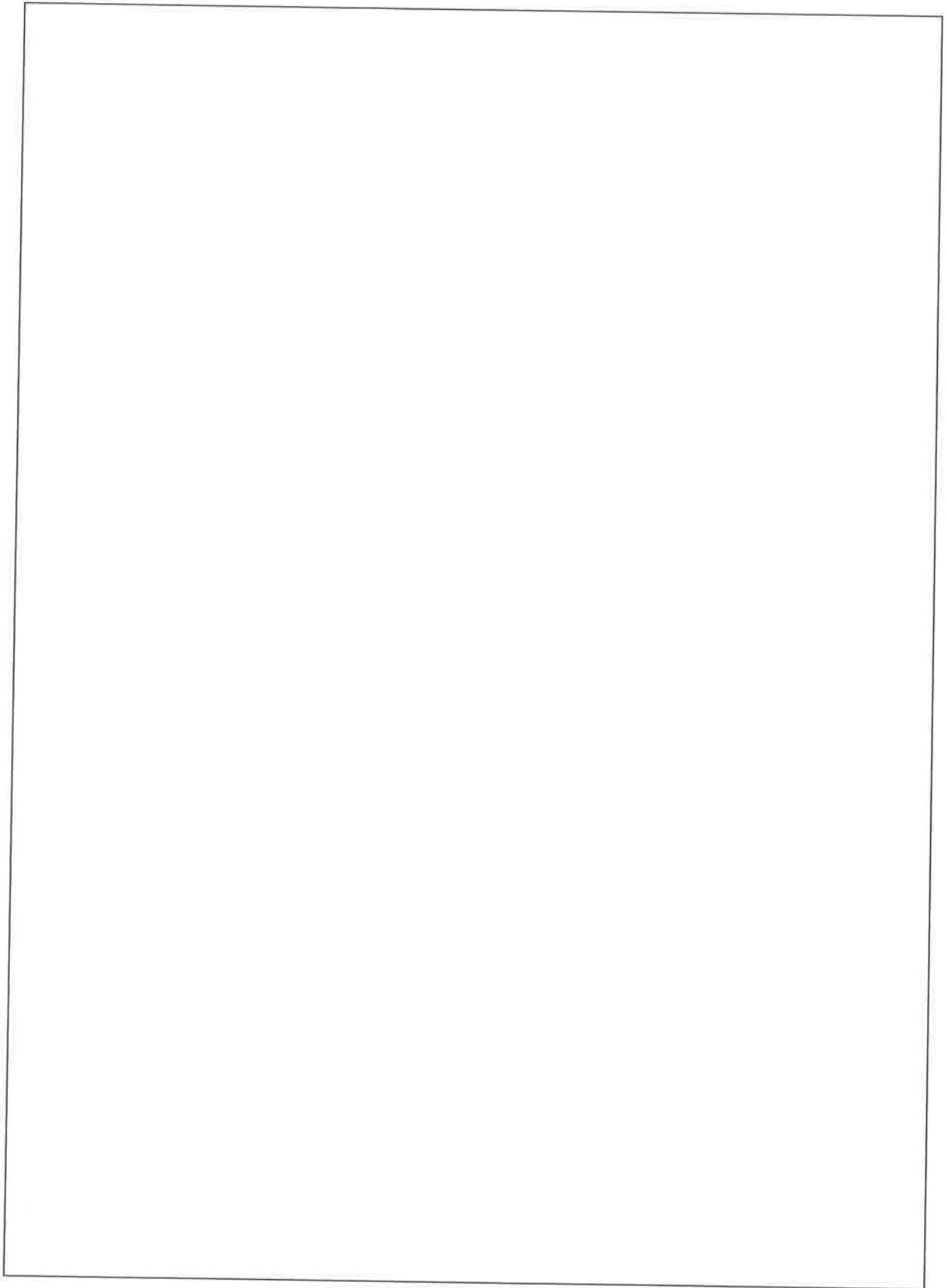
A large empty rectangular box provided for the student to write their answer to the problem.



3. 如圖所示，一半徑為 $R$ 、質量為 $m$ 、折射率為 $n$ 的透明玻璃半球被置在真空中。有一單色平行激光束均勻射向半球平截面的正中心。圖中，重力加速度 $g$ 向下，光束半徑 $\delta$ 遠小於 $R$ 。假設玻璃介質不吸收光，而且沒有界面反射。求能讓光壓平衡掉玻璃半球重量的激光功率 $P$ 。 $((\delta/R)^3$ 及更高量級可被忽略)

Shown in the figure, a transparent glass hemisphere of radius  $R$ , mass  $m$ , and refractive index  $n$  is placed in vacuum, where a monochromatic parallel beam is uniformly incident on the center of its flat sectioning at normal direction. The gravitational acceleration  $g$  is downward and the circular beam profile has a radius  $\delta$  much smaller than  $R$ . Assume the glass medium is absorption free and there are no interface reflections. Find the laser power  $P$  such that the radiation pressure can balance out the weight of the glass hemisphere.  $((\delta/R)^3$  and higher order terms can be ignored.)



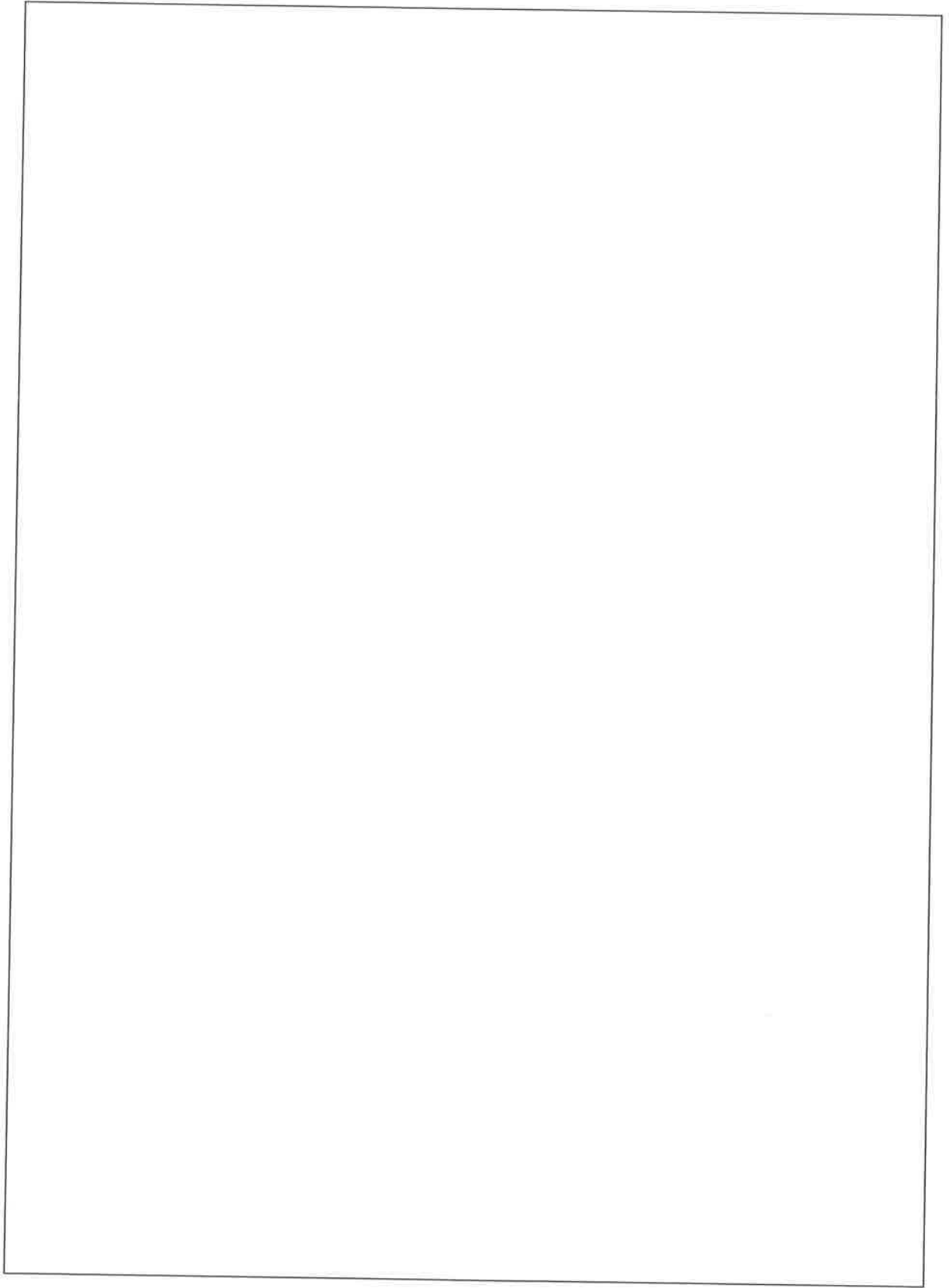


4. 考慮一質量為 $M$ 、長度為 $l$ 的鏈條垂直懸挂，其底部與一秤的托盤相接。現釋放該鏈條使其落在秤上，那麼當長度 $x$ 的部分鏈條墜落入托盤後，秤的讀數是多少？（可忽略空氣阻力和鏈條的粗細）

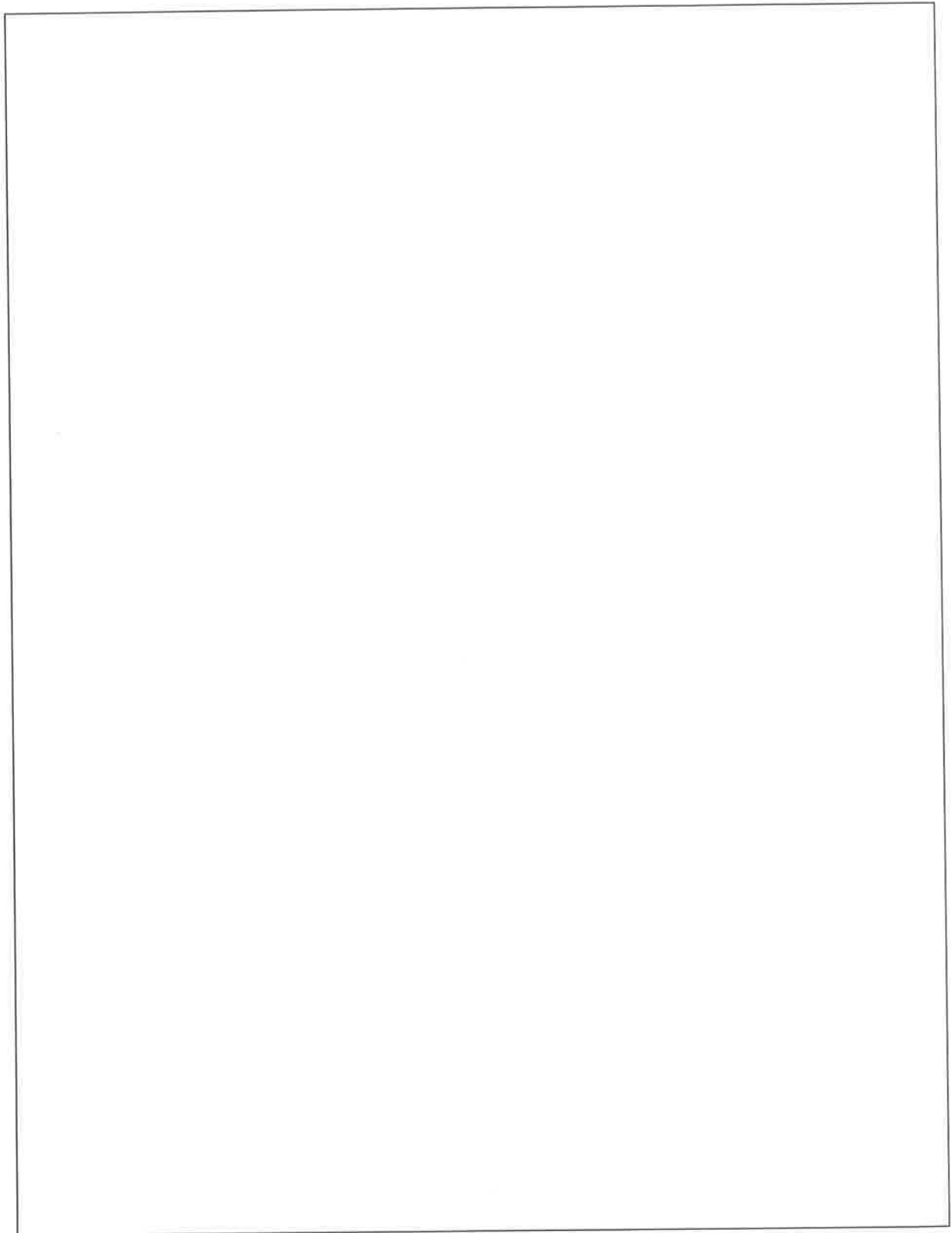
A chain of mass  $M$  and length  $l$  is suspended vertically with its lowest end touching a scale. The chain is released and falls onto the scale. What is the reading of the scale when a length  $x$  of the chain has fallen onto it? (Neglect air friction and the link sizes.)



A large empty rectangular box for writing the solution to the problem.



補充頁 1



補充頁 2

