

國立臺灣大學機械工程學系 104 學年度

大學甄選入學綜合評量筆試試題本

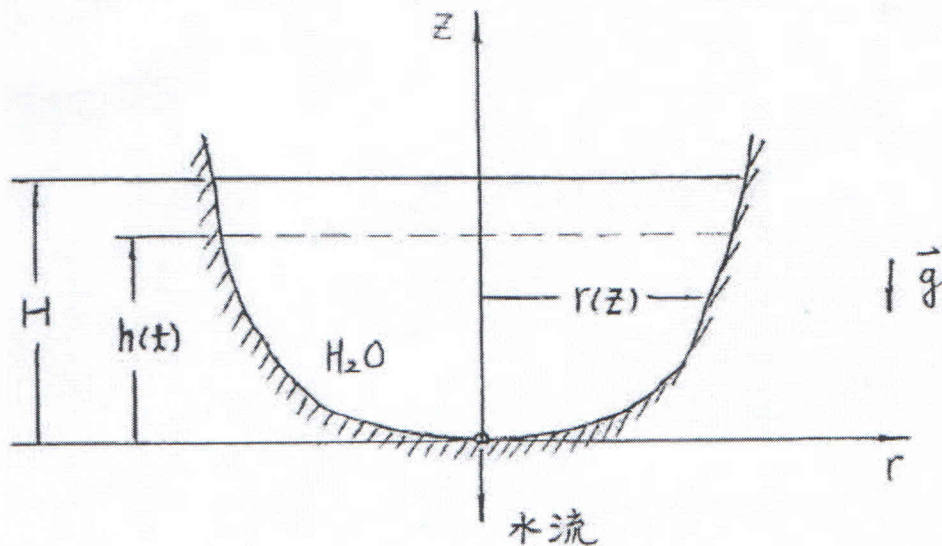
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* 考試時間：100 分鐘
不得參考圖書等資料

- 請注意： 1. 題目共有 4 大題，請儘量作答，滿分為 100 分。
2. 請在另附的試卷上作答。
3. 本試題紙請務必隨試卷繳回。

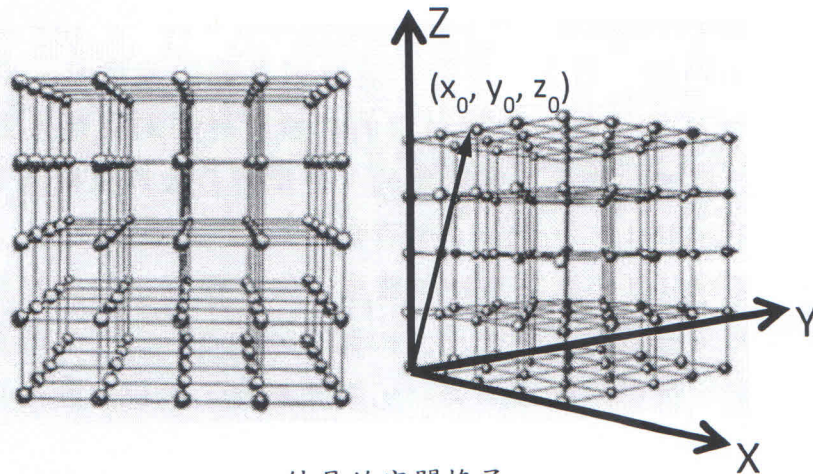
1. (25%) 古代的埃及人非常聰明，曾發明“水漏”來計時。所發明的水漏約如圖所示，為一半徑等於 $r(z)$ 的大圓形水缸，水缸的底部開有一半徑為 a 的小圓洞，且 $a \ll r(z)$ 。

茲假設原先水漏內的水位在 $z = H$ 的位置，當水漏裡的水因受重力場的作用，將水位下降的位能轉換成動能時，水漏裡的水便開始由底部的小圓洞向下流出，水漏於是開始計時。請問水漏的形狀應如何設計，才能使得水漏裡的水位在同樣的單位時間尺度下降同樣的高度 S ？圖中 $h(t)$ 為開始計時後，水漏裡的瞬間水位高度，其中 t 代表時間。



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2. (25%) 金屬材料的性質與其晶粒(grain)內原子的排列有關。這種原子按照一定規則排列的方式可用結晶的空間格子(space lattice)表示，如下圖所示。為簡單表示金屬的結晶格子，通常用“能代表排列特性的最小單位”，即單位格子(unit lattice)表示。若單位格子為正立方體則稱為立方格子。



結晶的空間格子

對這些空間格子施力時，可能會使空間格子互相滑移產生變形。通常可以用格子直線表示滑移的方向。若在空間格子任取 X、Y、Z 為三座標軸時，可用任意平行該格子直線的向量表示滑移方向。方便起見，可以選擇通過原點的向量(如圖示)，並以向量終點之座標(x_0, y_0, z_0)表示任一格子直線方向。因為原點和座標軸是自由選定的，所以立方格子中的(1, 0, 0)、(0, 1, 0)、(0, 0, 1)、(-1, 0, 0)、(0, -1, 0)、(0, 0, -1)等 6 個方向在結晶學上是對等的 (即座標值的順序與正負號不影響格子直線在結晶學上的對等性)。試回答以下的問題：

- (a) (5%) 下列哪些格子直線方向與(-1, 2, 2)在結晶學上是對等的?(複選題)
(A) (1, 2, -2); (B) (1, -2, 2); (C) (2, 2, -1); (D) (2, -1, -1); (E) (2, -1, -2); (F) (-2, -1, -2);
(G) (-1, 2, 3); (H) (2, -1, 2)。
- (b) (10%) (1, 2, 3) 格子直線有幾個對等的方向?(例如: (1, 0, 0)有 6 個對等的方向, 包括(1, 0, 0)在內。) 請詳細列出解題過程。
- (c) (10%) (1, -1, 0) 格子直線有幾個對等的方向?(例如: (1, 0, 0)有 6 個對等的方向, 包括(1, 0, 0)在內。) 請詳細列出解題過程。

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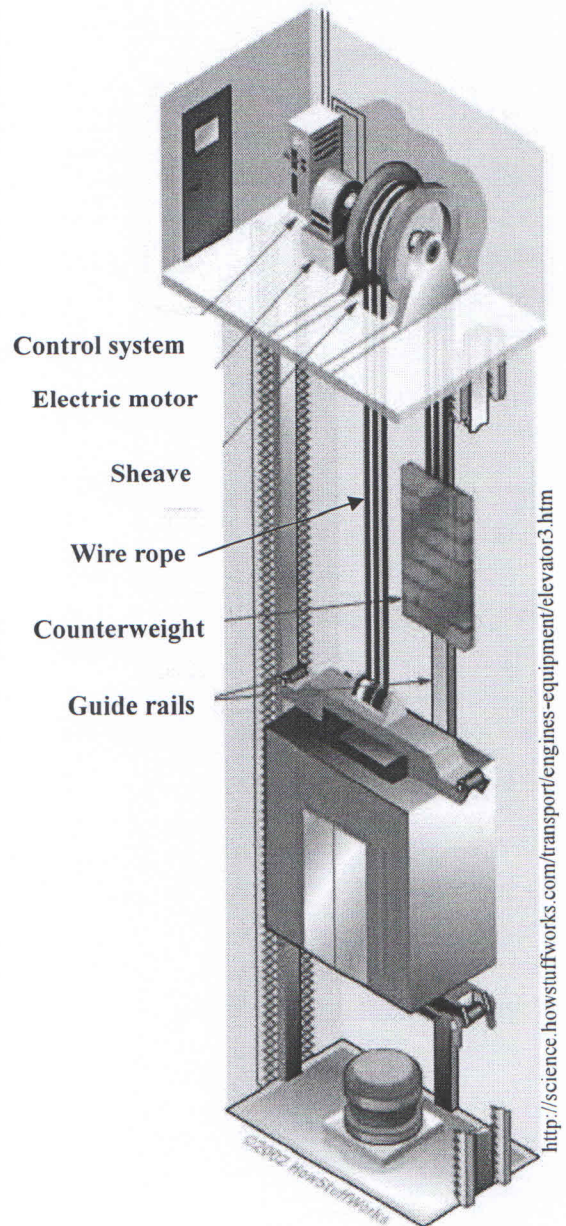
3. (30%) The Science of Cable-System Elevator

The schematic of an elevator system is shown on the right. The elevator car is moved by ropes looping around a motor-driven sheave. A sheave is just a pulley with grooves around the circumference. When the motor turns one way, the sheave raises the elevator; when the motor turns the other way, the sheave lowers the elevator. Conventionally the sheave, the motor and the control system are all housed in a machine room above the elevator shaft. Nowadays, machine-room-less elevators are gaining popularity.

The ropes that lift the car are also connected to a counterweight which weighs about 40% of the rated capacity of the elevator. The purpose of this balance is to conserve energy. With equal loads on each side of the sheave, it only takes a little bit of force to tip the balance one way or the other. Basically, the motor only has to overcome friction -- the weight on the other side does most of the work. Modern elevators may have regenerative systems to harvest the energy during braking and unbalanced movement of the car.

Both the elevator car and the counterweight ride on guide rails along the sides of the elevator shaft. The rails keep the car and counterweight from swaying back and forth, and they also work with the safety system to arrest the car in an emergency.

There are different elevator operating modes. For example, in the "Up Peak" mode, elevator cars in a group are recalled to the lobby and are dispatched one-by-one when they reach a pre-determined passenger load. The next elevator to be dispatched usually has a "this car leaving next" sign illuminated. An interesting mode is the "Sabbath mode" used in areas where the Sabbath prohibition against doing useful work is observed. In this mode, an elevator will stop automatically at every floor, allowing people to step on and off without having to press any buttons. Regenerative system is also disabled if it is normally used, shunting energy collected into a resistor network.



(Adapted from HowStuffWorks and The New World Encyclopedia)

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- (a) (5%) Name two things that might happen if there is no guide rail.
- (b) (5%) When do you think the “Up Peak” mode will most likely be used?
- (c) (5%) Can you explain why the regenerative system interferes with Sabbath prohibitions?
- (d) (7%) Tom is a diligent manager and is always the first one to arrive in early morning and the last one to leave in late evening. His office is on the tenth floor and the elevator has no regenerative system. As an environmentalist, Tom is willing to sacrifice riding the elevator once a day. Should you suggest him to give up riding up during arrival or riding down in the evening, please explain?
- (e) (8%) In the world’s tallest buildings (e.g. Burj Khalifa, The Shard), one cannot take a single elevator ride to go from ground to the top and has to change elevators at some intermediate level “Sky lobby”, can you try to offer some explanations?

4. (20%) 細觀近代物理與光電磁學理論的發展，會發現利用簡單的實驗設計，就可以量測出許多物理量的特性。同時培養動手設計實驗的能力，在理工科系中非常的重要。密立坎(Robert Millikan)與他的學生夫列契(Harvey Fletcher)，在 1909 至 1912 年間，利用著名的「油滴實驗」第一次測定出電子所帶的電荷。試問：

- (a) (12%) 試描述他們所設計的「油滴實驗」的實驗流程與儀器架設？
- (b) (8%) 試提出其他種實驗設計，可以用來測定電子所帶的電荷？

(提示：在油滴實驗中，方法主要是利用平衡重力與電力的關係式，而在近代物理中，磁力也是一種極為方便使用的力場之一。)