Chapter **14** **Fluids**

01. The air inside pushes outward with a force given by p_iA, where p_i is the pressure inside the room and A is the area of the window. Similarly, the air on the outside pushes inward with a force given by p_oA, where p_o is the pressure outside. The magnitude of the net force is $F = (p_i - p_o)A$. Since 1 atm = 1.013×10^5 Pa, F = (1.0 atm − 0.96 atm)(1.013×10^5 Pa/atm)(3.4 m)(2.1 m) = 2.9×10^4 N.

05. Let the volume of the expanded air sacs be V_a and that of the fish with its air sacs collapsed be V. Then $\rho_{\text{fish}} = m_{\text{fish}}/V = 1.08$ g/cm^3 and $\rho_w = m_{\text{fish}}/(V+V_a) = 1.00$ g/cm^3, where ρ_w is the density of the water. This implies $\rho_{\text{fish}}V = \rho_w(V+V_a)$ or $(V+V_a)/V = 1.08/1.00$, which gives $V_a/(V+V_a) = 7.4\%$.

07. (**a**) The pressure difference results in forces applied as shown in the figure. We consider a team of horses pulling to the right. To pull the sphere apart, the team must exert a force at least as great as the horizontal component of the total force determined by "summing" (actually, integrating) these force vectors. We consider a force vector at angle θ. Its leftward component is $\Delta p\cos\theta dA$, where dA is the area element for where the force is applied. We make use of the symmetry of the problem and let dA be that of a ring of constant θ on the surface. The radius of the ring is $r = R\sin\theta$, where R is the radius of the sphere. If the angular width of the ring is $d\theta$, in radians, then its width is $R\,d\theta$ and its area is $dA = 2\pi R^2\sin\theta d\theta$. Thus the net horizontal component of the force of the air is given by

$$F = 2\pi R^2\Delta p\int_0^{\pi/2}\sin\theta\cos\theta d\theta$$
$$= \pi R^2\Delta p\sin^2\theta\,|_0^{\pi/2} = \pi R^2\Delta p.$$

(**b**) We use 1 atm = 1.01×10^5 Pa to show that Δp = 0.90 atm = 9.09×10^4 Pa. The sphere radius is R = 0.30 m, so $F_h = \pi(0.30\text{ m})^2(9.09\times10^4\text{ Pa}) = 2.6\times10^4$ N. (**c**) One team of horses could be used if one half of the sphere is attached to a sturdy wall. The force of the wall on the sphere would balance the force of the horses.

11. The pressure p at the depth d of the hatch cover is $p_0 + \rho gd$, where ρ is the density of ocean water and p_0 is atmospheric pressure. The downward force of the water on the hatch cover is $(p_0+\rho gd)A$, where A is the area of the cover. If the air in the submarine is at atmospheric pressure then it exerts an upward force of p_0A. The minimum force that must be applied by the crew to open the cover has magnitude

$F = (p_0+\rho gd)A - p_0A = \rho gdA$
= (1024 kg/m^3)(9.8 m/s^2)(100 m)(1.2 m)(0.60 m)
= 7.2×10^5 N.

08. Note that 0.05 atm equals 5065 N/m^2. Application of Eq. 14-7 with the notation in this prob. leads to $d_{\max} = 5065/\rho_{\text{liquid}}g$, with SI units understood. Thus the difference of this quantity between fresh water (998 kg/m^3) and Dead Sea water (1500 kg/m^3) is

$$d_{\max} = \frac{5065}{9.8}\left(\frac{1}{998} - \frac{1}{1500}\right) = 0.17\text{ (m)}.$$

15. When the levels are the same the height of the liquid is $h = (h_1+h_2)/2$, where h_1 and h_2 are the original heights. Suppose h_1 is greater than h_2. The final situation can then be achieved by taking liquid with volume $A(h_1-h)$ and mass $\rho A(h_1-h)$, in the first vessel, and lowering it a distance $h - h_2$. The work done by the force of gravity is $W = \rho A(h_1-h)g(h-h_2)$. We substitute $h = (h_1+h_2)/2$ to obtain

$W = (¼)\rho gA(h_1-h_2)^2$
$= (¼)(1.30\times10^3)(9.80)(4.00\times10^{-4})(1.56-0.854)^2$
= 0.635 (J).

19. (**a**) At depth y the gauge pressure of the water is $p = \rho gy$, where ρ is the density of the water. We consider a horizontal strip of width W at depth y, with (vertical) thickness dy, across the dam. Its area is $dA = Wdy$ and the force it exerts on the dam is $dF = pdA = \rho gyWdy$. The total force of the water on the dam is

$$F = \int_0^D \rho gWydy = \frac{1}{2}\rho gWD^2 = \frac{1}{2}(1.00\times10^3\text{ kg/m}^3)$$
$$(9.80\text{ m/s}^2)(314\text{ m})(35.0\text{ m})^2 = 1.88\times10^9\text{ N}$$

(**b**) Again we consider the strip of water at depth y. Its moment arm for the torque it exerts about O is $D - y$ so the torque it exerts is $d\tau = dF(D-y) = \rho gyW(D-y)dy$ and the total torque of the water is

$$\tau = \int_0^D \rho gyW(D-y)dy = \rho gW\left(\frac{1}{2}-\frac{1}{3}\right)D^3 = \frac{1}{6}\rho gWD^3$$
$$= \tfrac{1}{6}(1.00\times10^3)(9.80)(314)(35.0)^3 = 2.20\times10^{10}\text{ N}\cdot\text{m}$$

(**c**) We write $\tau = rF$, where r is the effective moment arm. Then,

$$r = \frac{\tau}{F} = \frac{\rho gWD^3/6}{\rho gWD^2/2} = \frac{D}{3} = \frac{35.0}{3} = 11.7\text{ (m)}.$$

20. The gauge pressure you can produce is

$p = -\rho gh = -(1000)(9.8)(4.0\times10^{-2})/(1.01\times10^5)$
$= -3.9\times10^{-3}$ (atm),

where the minus sign indicates that the pressure inside your lung is less than the outside pressure.

22. (**a**) According to Pascal's principle $F/A = f/a \Rightarrow F = (A/a)f$. (**b**) We obtain

$$f = \frac{a}{A}F = \frac{(3.80\text{ cm})^2}{(53.0\text{ cm})^2}(20.0\times10^3\text{ N}) = 103\text{ N}.$$

The ratio of the squares of diameters is equivalent to the ratio of the areas. We also note that the area units cancel.

26. (**a**) The pressure (including the contribution from the atmosphere) at a depth of $h_{\text{top}} = L/2$ (corresponding to the top of the block) is

$$p_{top} = p_{atm} + \rho g h_{top} = [1.01\times10^5 + (1030)(9.8)(0.300)] = 1.04\times10^5 \text{ (Pa)},$$

where the unit Pa (Pascal) is equivalent to N/m^2. The force on the top surface (of area $A = L^2 = 0.36$ m^2) is $F_{top} = p_{top}A = 3.75\times10^4$ N. (**b**) The pressure at a depth of $h_{bot} = 3L/2$ (that of the bottom of the block) is $p_{bot} = p_{atm} + \rho g h_{bot}$

$= [1.01\times10^5 + (1030)(9.8)(0.900)] = 1.10\times10^5$ (Pa), where we recall that the unit Pa (Pascal) is equivalent to N/m^2. The force on the bottom surface is $F_{bot} = p_{bot}A = 3.96\times10^4$ N. (**c**) Taking the difference $F_{bot}–F_{top}$ cancels the contribution from the atmosphere (including any numerical uncertainties associated with that value) and leads to

$$F_{bot} - F_{top} = \rho g(h_{bot}-h_{top})A = \rho g L^3 = 2.18\times10^3 \text{ (N)},$$

which is to be expected on the basis of Archimedes' principle. Two other forces act on the block: an upward tension T and a downward pull of gravity mg. To remain stationary, the tension must be

$$T = mg - (F_{bot}-F_{top}) = (450)(9.80) - 2.18\times10^3 = 2.23\times10^3 \text{ (N)}.$$

(**d**) This has already been noted in the previous part: $F_b = 2.18\times10^3$ N, and $T + F_b = mg$.

29. (**a**) Let V be the volume of the block. Then, the submerged volume is $V_s = 2V/3$. Since the block is floating, the weight of the displaced water is equal to the weight of the block, so $\rho_w V_s = \rho_b V$, where ρ_w is the density of water, and ρ_b is the density of the block. We substitute $V_s = 2V/3$ to obtain

$$\rho_b = 2\rho_w/3 = 2(1000 \text{ kg/m}^3)/3 = 6.7\times10^2 \text{ kg/m}^3.$$

(**b**) If ρ_o is the density of the oil, then Archimedes' principle yields $\rho_o V_s = \rho_b V$. We substitute $V_s = 0.90V$ to obtain $\rho_o = \rho_b/0.90 = 7.4\times10^2$ kg/m^3.

43. Suppose that a mass Δm of water is pumped in time Δt. The pump increases the potential energy of the water by Δmgh, where h is the vertical distance through which it is lifted, and increases its kinetic energy by (½)Δmv^2, where v is its final speed. The work it does is $W = \Delta mgh + (½)\Delta mv^2$ and its power is

$$P = \frac{\Delta W}{\Delta t} = \frac{\Delta m}{\Delta t}(gh + \frac{1}{2}v^2)$$

Now the rate of mass flow is $\Delta m/\Delta t = \rho_w Av$, where ρ_w is the density of water and A is the area of the hose. The area of the hose is $A = \pi r^2 = \pi(0.010 \text{ m})^2 = 3.14\times10^{-4}\text{m}^2$ and $\rho_w Av = (1000\text{kg/m}^3)(3.14\times10^{-4} \text{ m}^2)(5.00 \text{ m/s}) = 1.57$ kg/s. Thus,

$$P = \rho Av[\rho g + \tfrac{1}{2}v^2] = (1.57 \text{ kg/s})[(9.80 \text{ m/s}^2)(3.0 \text{ m}) + (½)(5.0 \text{ m/s})^2] = 66 \text{ W}.$$

45. (**a**) We use the Eq. of continuity: $A_1v_1 = A_2v_2$. Here A_1 is the area of the pipe at the top and v_1 is the speed of the water there; A_2 is the area of the pipe at the bottom and v_2 is the speed of the water there. Thus $v_2 = (A_1/A_2)v_1 = [(4.0 \text{ cm}^2)/(8.0 \text{ cm}^2)] (5.0 \text{ m/s}) = 2.5$m/s.

(**b**) We use the Bernoulli Eq.: $p_1 + (½)\rho v_1^2 + \rho gh_1 = p_2 + (½)\rho v_2^2 + \rho gh_2$, where ρ is the density of water, h_1 is its initial altitude, and h_2 is its final altitude. Thus

$$p_2 = p_1 + \tfrac{1}{2}\rho(v_1^2-v_2^2) + \rho g(h_1-h_2) = 1.5\times10^5 + \tfrac{1}{2}(1.0\times10^3)(5.0^2-2.5^2) + (1.0\times10^3)(9.8)(10) = 2.6\times10^5 \text{ (Pa)}.$$

54. (**a**) The volume of water (during 10 minutes) is $V = (v_1 t)A_1 = (15 \text{ m/s})(10 \text{ min})(60 \text{ s/min})(\pi/4)(0.03 \text{ m})^2 = 6.4 \text{ m}^3$. (**b**) The speed in the left section of pipe is

$$v_2 = v_1(\frac{A_1}{A_2}) = v_1(\frac{d_1}{d_2})^2 = (15)(\frac{3.0}{5.0})^2 = 5.4 \text{ (m/s)}.$$

(**c**) Since $p_1 + (½)\rho v_1^2 + \rho gh_1 = p_2 + (½)\rho v_2^2 + \rho gh_2$ and $h_1 = h_2$, $p_1 = p_0$, which is the atmospheric pressure,

$$p_2 = p_0 + \tfrac{1}{2}\rho(v_1^2-v_2^2) = 1.01\times10^5 + \tfrac{1}{2}(1.0\times10^3)(15^2-5.4^2) = 1.99\times10^5 \text{ (Pa)} = 1.97 \text{ (atm)}.$$

Thus the gauge pressure is (1.97 atm – 1.00 atm) = 0.97 atm = 9.8×10^4 Pa.

55. (**a**) Since S.P. 14-8 deals with a similar situation, we use the final Eq. (labeled "Answer") from it: $v = (2gh)^{1/2} \Rightarrow v = v_0$ for the projectile motion. The stream of water emerges horizontally ($\theta_0 = 0°$ in the notation of Chapt. 4), and setting $y - y_0 = -(H-h)$ in Eq. 4-22, we obtain the "time-of-flight"

$$t = \sqrt{\frac{-2(H-h)}{-g}} = \sqrt{\frac{2}{g}(H-h)}\ .$$

Using this in Eq. 4-21, where $x_0 = 0$ by choice of coordinate origin, we find

$$x = v_o t = \sqrt{2gh}\sqrt{2(H-h)/g} = 2\sqrt{h(H-h)} = 2\sqrt{10(40-10)} = 35 \text{ (m)}.$$

(**b**) The result of part (a) (which, when squared, reads $x^2 = 4h(H-h)$) is a quadratic Eq. for h once x and H are specified. Two solutions for h are therefore mathematically possible, but are they both physically possible? For instance, are both solutions positive and less than H? We employ the quadratic formula:

$$h^2 - Hh + \frac{1}{4}x^2 = 0 \Rightarrow h = \frac{1}{2}(H \pm \sqrt{H^2 - x^2}),$$

which permits us to see that both roots are physically possible, so long as $x \le H$. Labeling the larger root h_1 (where the plus sign is chosen) and the smaller root as h_2 (where the minus sign is chosen), then we note that their sum is simply

$$h_1 + h_2 = \frac{1}{2}(H + \sqrt{H^2 - x^2}) + \frac{1}{2}(H - \sqrt{H^2 - x^2}) = H.$$

Thus, one root is related to the other (generically labeled h' and h) by $h' = H - h$. Its numerical value is $h' = 40$ cm $-$ 10 cm = 30 cm. (**c**) We wish to maximize the function $f = x^2 = 4h(H-h)$. We differentiate with respect to h and set equal to zero to obtain

$$df/dh = 4H - 8h = 0 \quad\Rightarrow\quad h = H/2,$$

or h = (40 cm)/2 = 20 cm, as the depth from which an emerging stream of water will travel the maximum horizontal distance.

69.• (**a**) We consider a point D on the surface of the liquid in the container, in the same tube of flow with points A, B and C. Applying Bernoulli's Eq. to points D and C, we obtain

$$p_D + \tfrac{1}{2}\rho v_D^2 + \rho g h_D = p_C + \tfrac{1}{2}\rho v_C^2 + \rho g h_C ,$$

which leads to

$$v_c = \sqrt{\frac{2(p_D - p_C)}{\rho} + 2g(h_D - h_C) + v_D^2} \approx \sqrt{2g(d + h_2)} .$$

where in the last step we set $p_D = p_C = p_{\text{air}}$ and $v_D/v_C \approx 0$. Plugging in the values, we obtain

$$v_c = \sqrt{2(9.8)(0.40 + 0.12)} = 3.2 \text{ (m/s)}.$$

(**b**) We now consider points B and C:

$$p_B + \tfrac{1}{2}\rho v_B^2 + \rho g h_B = p_C + \tfrac{1}{2}\rho v_C^2 + \rho g h_C .$$

Since $v_B = v_C$ by Eq. of continuity, and $p_C = p_{\text{air}}$, Bernoulli's Eq. becomes

$$p_B = p_C + \rho g(h_C - h_B) = p_{\text{air}} - \rho g(h_1 + h_2 + d)$$
$$= 1.0\times10^5 - (1.0\times10^3)(9.8)(0.25+0.40+0.12)$$
$$= 9.2\times10^4 \text{ (Pa)}.$$

(**c**) Since $p_B \ge 0$, we must let $p_{\text{air}} - \rho g(h_1 + d + h_2) \ge 0$, which yields

$$h_1 \le h_{1,\max} = \frac{p_{\text{air}}}{\rho} - d - h_1 \le \frac{p_{\text{air}}}{\rho} = 10.3 \text{ m}.$$

80.• The absolute pressure is

$p = p_0 + \rho g h = 1.01\times10^3$ Pa + (1.03×10^3 kg/m^3) (9.80 m/s^2)(150 m) = 1.62×10^4 Pa.

84.• (**a**) Using Eq. 14-10, we have $p_g = \rho g h = 1.21\times10^7$ Pa. (**b**) By definition, $p = p_g + p_{\text{atm}} = 1.22\times10^7$ Pa. (**c**) We interpret the question as asking for the total force *compressing* the sphere's surface, and we multiply the pressure by total area: $p(4\pi r^2) = 3.82\times10^5$ N. (**d**) The (upward) buoyant force exerted on the sphere by the seawater is $F_b = \rho_w g V$, where $V = (4/3)\pi r^3$. Therefore, F_b = 5.26N. (**e**) Newton's second law applied to the sphere (of mass m = 7.00 kg) yields $F_b - mg = ma$, which results in $a = -9.04$ m/s^2, which means the acceleration vector has a magnitude of 9.04m/s^2. (**f**) The direction is downward.

92.• (**a**) We assume that the top surface of the slab is at the surface of the water and that the automobile is at the center of the ice surface. Let M be the mass of the automobile, ρ_i be the density of ice, and ρ_w be the density of water. Suppose the ice slab has area A and thickness h. Since the volume of ice is Ah, the downward force of gravity on the automobile and ice is $(M+\rho_i Ah)g$. The buoyant force of the water is $\rho_w Ahg$, so the condition of equilibrium is $(M+\rho_i Ah)g - \rho_w Ahg = 0$ and

$$A = \frac{M}{(\rho_w - \rho_i)h} = \frac{1100}{(998-917)(0.30)} = 45 \text{ (m}^2\text{)}.$$

These density values are found in Table 14-1 of the text. (**b**) It does matter where the car is placed since the ice tilts if the automobile is not at the center of its surface.

91.• Equilibrium of forces (on the floating body) is expressed as $F_b = m_{\text{body}} g \Rightarrow \rho_{\text{liquid}} g V_{\text{submerged}} = \rho_{\text{body}}\, g\, V_{\text{total}}$, which leads to

$$\frac{V_{\text{submerged}}}{V_{\text{total}}} = \frac{\rho_{\text{body}}}{\rho_{\text{liquid}}} .$$

We are told (indirectly) that two-thirds of the body is below the surface, so the fraction above is 2/3. Thus, with $\rho_{\text{body}} = 0.98\,\text{g/cm}^3$, we find $\rho_{\text{liquid}} \approx 1.5\,\text{g/cm}^3$ — certainly much more dense than normal seawater (the Dead Sea is about seven times saltier than the ocean due to the high evaporation rate and low rainfall in that region).

59.* (**a**) The continuity Eq. yields $Av = aV$, and Bernoulli's Eq. yields $\Delta p + (½)\rho v^2 = (½)\rho V^2$, where $\Delta p = p_1 - p_2$. The first Eq. gives $V = (A/a)v$. We use this to substitute for V in the second Eq., and obtain $\Delta p + (½)\rho v^2 = (½)\rho(A/a)^2V^2$. We solve for v. The result is

$$v = \sqrt{\frac{2\Delta p}{\rho[(A^2/a^2)-1]}} = \sqrt{\frac{2a^2\Delta p}{\rho(A^2-1)}} .$$

(**b**) We substitute values to obtain

$$v = \sqrt{\frac{2(32\times10^{-4})(55\times10^3 - 41\times10^3)}{(1000)[(64\times10^{-4})^2 - (32\times10^{-4})^2]}} = 3.06 \text{ (m/s)}.$$

Consequently, the flow rate is $Av = (64\times10^{-4}$ m^2) (3.06 m/s) = 2.0×10^{-2} m^3/s .

61.* (**a**) Bernoulli's Eq. gives $p_A = p_B + (½)\rho_{\text{air}} v^2$, But $\Delta p = p_A - p_B. = \rho g h$ in order to balance the pressure in the two arms of the U-tube. Thus $\rho g h = (½)\rho_{\text{air}} v^2$,

or $$v = \sqrt{\frac{2\rho g h}{\rho_{air}}}.$$

(**b**) The plane's speed relative to the air is

$$v = \sqrt{\frac{2(810)(9.8)(0.260)}{1.03}} = 63.3 \text{ (m/s)}.$$

♦**靜流體壓力**($v = 0$)：壓力 p + 重力位能密度ρgy = 常數 ♦**連續方程式**：體流率 Av =常數 ♦**柏努利方程式**：壓力 p + 動能密度$(½)\rho v^2$ + 重力位能密度ρgy = 常數 ♦**亞基米得原理**：一部份或完全浸於流體內的物體，被一等於其排開流體重量之力所浮升，即**浮力** $F_B = \rho_f Vg$。

重點整理－第 14 章 流體

什麼造成抓地效應？又為什麼它會消失？

密度 任一物質的密度ρ定義爲每單位體積的質量：

$$\rho = \Delta m/\Delta V. \qquad (14\text{-}1)$$

通常物質試樣遠大於原子尺度，14-1 式可寫爲

$$\rho = m/V. \qquad (14\text{-}2)$$

流體壓力 流體爲可流動的物質；其因無法承受切應力，形狀隨容器形狀而改變；然而它能施加一垂直於其表面的力，該力可藉壓力 p 以描述：

$$p = \Delta F/\Delta A, \qquad (14\text{-}3)$$

其中ΔF 爲作用於面積ΔA 之表面元素的力。假如力均勻施於平坦表面上，則 14-3 式可寫爲

$$p = F/A. \qquad (14\text{-}4)$$

於流體中某特定點由流體壓力產生的力，其大小於各方向均相等。**計示壓力**爲在某點真實的壓力(或絕對壓力)與大氣壓力之差。

壓力隨高度及深度變化 在靜止流體內壓力隨鉛直位置 y 而改變，對 y 向上取正而言，

$$p_2 = p_1 + \rho g(y_1 - y_2). \qquad (14\text{-}7)$$

流體內所有同一高度的點之壓力均相等。假如 h 爲流體試樣在壓力爲 p_0 某參考高度之下的深度，14-7 式變爲

$$p = p_0 + \rho g h, \qquad (14\text{-}8)$$

式中 p 爲試樣內的壓力。

J1.**鯊魚裝與機器魚—淺談仿生減阻與仿生推進**，陳政宏，科學發展 365 期(9205) 56。
J2.**百年來人類飛行動力的演進**，蔣小偉，科學發展 378 期(9306) 42。
J3.**大氣中的狂暴舞者—龍捲風**，李健成，科學發展 378 期(9306) 52。
J4.**旋，還是不旋—變化球問題**，李志揚、陳政宏，科學發展 388 期(9404) 54。
J7.**飛行夢想的實踐者—萊特兄弟**，王裕宏，科學發展 376 期 (9304) 6。
J5.*Q&A*.**高爾夫球上的小洞有什麼作用**？科學人 2004 年 5 月號。
J6.*Q&A*.**正常血壓值為什麼應小於 120/ 80？為什麼不會隨身高改變？**科學人 2005 年 5 月。
J8.**耀眼的六百年—鄭和與〈鄭和航海圖〉**，龍村倪，科學發展 379 期(9307) 42。

帕斯卡原理 施於密閉容器中流體之壓力改變量，必不減地傳遞至流體每一部份與容器壁上。

亞基米德原理 當物體完全或部份浸於流體中，週遭的流體作用於物體造成一浮力 $\vec{F}_b$。此力垂直向上且其大小爲 $F_b = m_f g$, (12-24)

式中 m_f 爲物體所排開流體的質量(亦即被物體排擠出的流體)。

當物體浮於流體上，作用於物體的(向上)浮力大小 F_b 等於作用於物體的(向下)重力大小 F_g。浮力作用的物體之視重與真實重量的關係爲

$$\text{weight}_{app} = \text{weight} - F_b \qquad (14\text{-}19)$$

理想流體流動 理想流體爲不可壓縮且無黏滯性，並且其流動爲穩定的且無旋的。**流線**爲各流體質點所依循的路徑。**流動管**爲一整束流線。於任一流動管中流動遵循連續方程式：

$$R_v = Av = \text{常數}, \qquad (12\text{-}25)$$

其中 R_v 爲體積流率，A 爲流管中任意點的截面積，而 v 爲該點流體速率。質量流率 R_m 爲

$$R_m = \rho R_v = \rho A v = \text{常數}. \qquad (14\text{-}25)$$

柏努利方程式 應用力學能守恆原理於理想流體之流動導出沿著任意流動管之柏努利方程式：

$$p + \tfrac{1}{2}\rho v^2 + \rho g y = \text{常數} \qquad (14\text{-}29)$$

(如發現錯誤煩請告知 jyang@mail.ntou.edu.tw, Thanks.)

Archimedes 亞基米得; Bernoulli 柏努利; Pascal 帕斯卡; Rayleigh 瑞立; Torricelli 托里切利; fluid 流體; flow 流動; tube of flow 流動管; laminar flow;層流; equation of continuity 連續方程式; mass/volume flow rate 質/體流率; Mercury barometer 水銀氣壓計; open-tube manometer 開管壓力計; pressure 壓力; absolute/gauge pressure 絕對/計示壓力; systolic/diastolic pressure 收縮/舒張壓; mm Hg 毫米汞柱; dam 水壩; hydraulic lever 液壓槓桿; flap 副翼; siphon 虹吸管; wing 尾翼,擾流板; buoyant force 浮力; density 密度; desperado 歹徒; dye 染料; Ethanol 乙醇; Heimlich maneuver 海姆利胥急救法; negative lift 負升力; nonviscous 無黏滯的; pilot tube 領示管; irrotational 無旋的; scuba 水肺; streamline 流線; torpedo 魚雷; turbulent 急,湍流的; venturi meter 文士里計量計;

•**備忘錄**•