77. Assuming the horizontal velocity of the ball is *constant*, the horizontal displacement is $\Delta x = v\Delta t$, where Δx is the horizontal distance traveled, Δt is the time, and v is the (horizontal) velocity. With v = 160 km/h = 44.4 m/s, we have

$$\Delta t = \frac{\Delta x}{\Delta t} = \frac{18.4}{44.4} = 0.414\ (\text{s}).$$

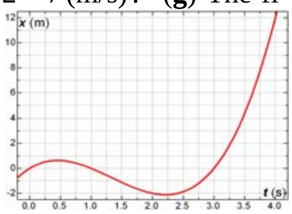
04. With 1 m/s = 3.6 km/h, Huber's speed is

$$v_0 = (200\,\text{m})/(6.509\,\text{s}) = 30.72\,\text{m/s} = 110.6\,\text{km/h}.$$

Since Whittingham beat Huber by 19.0 km/h, his speed is $v_1 = 110.6 + 19.0 = 129.6$ (km/h), or 36.00 m/s. Thus, the time through a distance of 200 m for Whittingham is

$$\Delta t = \Delta x / v_1 = (200\,\text{m})/(36.00\,\text{m/s}) = 5.554\,\text{s}.$$

05. Using $x = 3t - 4t^2 + t^3$ with SI units understood is efficient (and is the approach we will use), but if we wished to make the units explicit we would write $x = (3\,\text{m/s})\,t - (4\,\text{m/s}^2)\,t^2 + (1\,\text{m/s}^3)\,t^3$. We will quote our answers to one or two significant figures, and not try to follow the significant figure rules *rigorously*. (**a**) Plugging in $t = 1$ s yields $x = 3 - 4 + 1 = 0$. (**b**) With t = 2 s we obtain $x = 3(2) - 4(2)^2 + (2)^3 = -2$ (m). (**c**) With $t = 3$ s we have $x = 0$ m. (**d**) Plugging in $t = 4$ s gives x = 12 m. For later reference, we also note that the position at t = 0 is x = 0. (**e**) The position at t = 0 is subtracted from the position at t = 4 s to find the displacement x = 12 m. (**f**) The position at $t = 2$ s is subtracted from the position at t = 4 s to give the displacement x = 14 m. Eq.2-2, then, leads to $v_{\text{av}} = \Delta x / \Delta t = 14/2 = 7$ (m/s). (**g**) The figure is shown for horizontal axis of $0 \le t \le 4$ s. Draw a straight line from the point at (2, –2) to that at (4, 12), whose slope give the answer for part (f).



07. Converting to seconds, the running times are t_1 = 147.95 s and t_2 = 148.15 s, respectively. If the runners were equally fast, then

$$S_{av1} = S_{av2} \quad \Rightarrow \quad L_1/t_1 = L_2/t_2\,.$$

From this we obtain $L_2 - L_1 =$

$$(\frac{t_2}{t_1} - 1)L_1 = (\frac{148.15}{147.95} - 1)L_1 = 0.00135L_1 \approx 1.4\ \text{m},$$

where we set $L_1 \approx 1000$ m in the last step. Thus, if L_1 and L_2 are no different than about 1.4 m, then runner 1 is indeed faster than runner 2. However, if L_1 is shorter than L_2 by more than 1.4 m, then runner 2 would actually be faster.

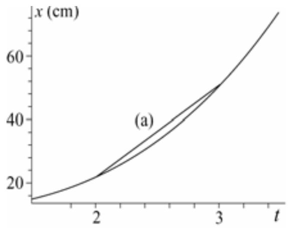
17. We use Eq.2-2 for average velocity and Eq.2-4 for instantaneous velocity, and work with distances in centimeters and times in seconds. (**a**) We plug into the given equation for x for t = 2.00 s and t = 3.00 s and obtain x_2 = 21.75 cm and x_3 = 50.25 cm, respectively. The average velocity during the time interval $2.00 \le t \le 3.00$ s is

$$v_{av} = \frac{\Delta x}{\Delta t} = \frac{50.25 - 21.75}{3.00 - 2.00},$$

which yields v_{av} = 28.5 cm/s. (**b**) The instantaneous velocity is $v = dx/dt = 4.5t^2$, which, at time t = 2.00 s, yields $v = 4.5)(2.00)^2 = 18.0$ (cm/s). (**c**) At t = 3.00 s, the instantaneous velocity is $v = (4.5)(3.00)^2 = 40.5$ (cm/s). (**d**) At t = 2.50 s, the instanttaneous velocity is $v = (4.5)(2.50)^2 = 28.1$ (cm/s). (**e**) Let t_m stand for the moment when the particle is midway between x_2 and x_3 [that is, when the particle is at $x_m = (x_2 + x_3)/2 = 36$ cm]. Therefore,

$$x_m = 9.75 + 1.5t_m^3 \quad \Rightarrow \quad t_m = 2.596\ \text{s}.$$

Thus, the instantaneous speed at this time is $v = 4.5 \times (2.596)^2 = 30.3$ (cm/s). (**f**) The answer to part (a) is given by the slope of the straight line between t = 2 & t = 3 in this x-vs-t plot. The answers to parts (b), (c), (d) and (e) correspond to the slopes of tangent lines (*not* shown but easily imagined) to the curve at the appropriate points.



20. (**a**) Taking derivatives of $x(t) = 12t^2 - 2t^3$, we obtain the velocity and the acceleration functions:

$$v(t) = 24t - 6t^2 \qquad \text{and} \qquad a(t) = 24 - 12t$$

with length in meters and time in seconds. Plugging in the value t = 3 yields $x(3)$ = 54 m.. (**b**) Similarly, plugging in the value t = 3 yields $v(3)$ = 18 m/s. (**c**) For t = 3, $a(3) = -12$ m/s^2. (**d**) At the maximum x, we must have v = 0; eliminating the t = 0 root, the velocity equation reveals $t = 24/6 = 4$ (s) for the time of maximum x. Plugging $t = 4$ into the equation for x leads to x = 64 m for the largest x value reached by the particle. (**e**) From (d), we see that the x reaches its maximum at t = 4.0 s. (**f**) A maximum v requires a = 0, which occurs when t = 24/12 = 2.0 (s). This, inserted into the velocity equation, gives $v_{\max}$ = 24 m/s. (**g**) From (f), we see that the maxi- mum of v occurs at t = 24/12 = 2.0 (s). (**h**) In part (e), the particle was (momentarily) motionless at t = 4 s. The acceleration at that time is readily found to be $24 - 12(4) = -24$ (m/s^2). (**i**) The *average velocity* is defined by Eq.2-2, so we see that the values of x at t = 0 and t = 3s are needed; these are, respectively, x = 0 and x = 54 m [found in part (a)]. Thus,

$$v_{\text{av}} = (54 - 0)/(3 - 0) = 18\ (\text{m/s}).$$

22. We use Eq.2-2 (average velocity) and Eq.2-7 (average acceleration). Regarding our coordinate choices, the *initial* position of the man is taken as the origin and his direction of motion during 5 min ≤ t ≤ 10 min is taken to be the $+x$ direction. We also use the fact that $\Delta x = v\Delta t'$ when the velocity is *constant* during a time interval $\Delta t'$. (**a**) The entire interval considered is $\Delta t = 8-2 = 6$ (min) which is equivalent to 360 s, whereas the sub-interval in which he is *moving* is only $\Delta t' = 8-5 = 3$ (min) = 180 (s). His position at $t = 2$ min is $x = 0$ and his position at $t = 8$ min is $x = v\Delta t' = (2.2)(180) = 396$ (m). Therefore,

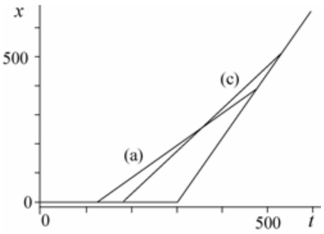
$$v_{av} = (396\,\text{m} - 0)/(360\,\text{s} - 0) = 1.10\ \text{m/s}.$$

(**b**) The man is at rest at $t = 2$ min and has velocity $v = 2.2$ m/s at $t = 8$ min. Thus, keeping the answer to 3 significant figures,

$$a_{av} = (2.2\ \text{m/s} - 0)/(360\ \text{s} - 0) = 0.00611\ \text{m/s}^2.$$

(**c**) Now, the entire interval considered is $\Delta t = 9 - 3 = 6$ (min) (360 s again), whereas the sub-interval in which he is moving is $\Delta t' = 9–5 = 4$ (min) = 240 (s). His position at $t = 3$ min is $x = 0$ and his position at $t = 9$ min is $x = v\Delta t' = (2.2)(240) = 528$ (m). Therefore, $v_{av} = (528\,\text{m} - 0)/(360\,\text{s} - 0) = 1.47$ m/s.

(**d**) The man is at rest at $t = 3$ min and has velocity $v = 2.2$ m/s at $t = 9$ min. Consequently, $a_{av} = 2.2/360 = 0.00611$ (m/s^2) just as in part (b). (**e**) The horizontal line near the bottom of this x-vs-t graph represents the man standing at $x = 0$ for $0 \le t < 300$ s and the linearly rising line for $300\,\text{s} \le t \le 600$ s represents his *constant-velocity* motion. The dotted lines represent the answers to part (a) and (c) in the sense that their slopes yield those results. The graph of v-vs-t is not shown here, but would consist of two horizontal "steps" (one at $v = 0$ for $0 \le t < 300$ s and the next at $v = 2.2$ m/s for $300\ \text{s} \le t \le 600$ s). The indications of the average accelerations found in parts (b) and (d) would be dotted lines connecting the "steps" at the appropriate t values (the slopes of the dotted lines representing the values of a_{av}). Using the above value for θ and $h = 1.7$ m, we have $r = 5.2\times10^6$ m.



29. We separate the motion into two parts, and take the direction of motion to be positive. In part 1, the vehicle accelerates from rest to its high- est speed; we are given $v_0 = 0$; $v = 20$ m/s and $a = 2.0$ m/s^2. In part 2, the vehicle decelerates from its highest speed to a halt; we are given $v_0 = 20$ m/s; $v = 0$ and $a = -1.0$ m/s^2 (negative because the acceleration vector points opposite to the direction of motion). (**a**) From Table 2-1, we find t_1 (the duration of part 1) from $v = v_0 + at$. In this way, $20 = 0 + 2.0t_1$ yields $t_1 = 10$ s. We obtain the duration t_2 of part 2 from the same equation. Thus, $0 = 20 + (-1.0)\,t_2$ leads to $t_2 = 20$ s, and the total is $t = t_1 + t_2 = 30$ s.

(**b**) For part 1, taking $x_0 = 0$, we use the equation $v^2 = v_0^2 + 2a(x - x_0)$ from Table 2-1 and find

$$x = \frac{v^2 - v_0^2}{2a} = \frac{20^2 - 0}{2(2.0)} = 100\ \text{(m)}.$$

This position is then the *initial* position for part 2, so that when the same equation is used in part 2 we obtain

$$x - 100 = \frac{v^2 - v_0^2}{2a} = \frac{0^2 - 20^2}{2(-1.0)}$$

Thus, the final position is $x = 300$ m. That this is also the total distance traveled should be evident (the vehicle did not "backtrack" or reverse its direction of motion).

30. The acceleration found from Eq.2-11 (or, suitably interpreted, Eq.2-7) is

$$a = \Delta v / \Delta t = (1020\ \text{km/h})/(1.4\ \text{s})$$
$$= (1020\ \text{m})/(3.6\times1.4\ \text{s}^2) = 202.4\ \text{m/s}^2.$$

In terms of the gravitational acceleration g, this is expressed as a multiple of 9.8 m/s^2 as follows:

$$a = (202.4/9.8)g = 20.6\,g = 21\,g.$$

34. (**a**) Eq.2-15 is used for part 1 of the trip and Eq. 2-18 is used for part 2: $\Delta x_1 = v_{0,1}\,t_1 + \frac{1}{2}a_1 t_1^2$,

where $a_1 = 2.25$ m/s^2 and $\Delta x_1 = 900/4$ m,

$$\Delta x_2 = v_2 t_2 - \tfrac{1}{2}a_2 t_2^2,$$

where $a_2 = -0.75$ m/s^2 and $\Delta x_2 = 3(900)/4$ m. In addition, $v_{0,1} = v_2 = 0$. Solving these equations for the times and adding the results gives $t = t_1 + t_2 = 56.6$ s.

(**b**) Eq. 2-16 is used for part 1 of the trip:

$$v^2 = (v_{0,1})^2 + 2a_1\Delta x_1$$
$$= 0 + 2(2.25)(900/4) = 1013\ (\text{m}^2/\text{s}^2),$$

which leads to $v = 31.8$ m/s for the maximum speed.

99•. We neglect air resistance, which justifies setting $a = -g = -9.8$ m/s^2 (taking *down* as the $-y$ direction) for the duration of the motion. We are allowed to use Table 2-1 (with Δy replacing Δx) because this is *constant* acceleration motion. When something is thrown straight *up* and is caught at the level it was thrown from (with a trajectory similar to that shown in Fig. 2-25), the time of flight t is half of its time of ascent t_a, which is given by Eq.2-18 with $\Delta y = H$ and $v = 0$ (indicating the maximum point).

$$H = v\,t_a + \tfrac{1}{2}g\,t_a^2 \ \Rightarrow\ t_a = \sqrt{2H/g}\,.$$

Writing these in terms of the total time in the air $t = 2t_a$ we have $H = \frac{1}{8}g\,t^2 \ \Rightarrow\ t = 2\sqrt{2H/g}$.

We consider two throws, one to height H_1 for total time t_1 and another to height H_2 for total time t_2, and we set up a ratio: $\dfrac{H_2}{H_1} = \dfrac{gt_2^2/8}{gt_1^2/8} = (\dfrac{t_2}{t_1})^2$

from which we conclude that if $t_2 = 2t_1$ (as is required by the problem) then $H_2 = 2^2H_1 = 4H_1$.

105•. We neglect air resistance, which justifies setting $a = -g = -9.8\,\text{m/s}^2$ (taking *down* as the $-y$ direction) for the duration of the stone's motion. We are allowed to use Table 2-1 (replacing x by y) because the ball has *constant* acceleration motion (and we choose $y_0 = 0$). (**a**) We apply Eq.2-16 to both measurements, with SI units understood.

$$v_B{}^2 = v_0{}^2 - 2gy_B \quad\Rightarrow\quad (\tfrac{1}{2}v)^2 + 2g(y_A+3) = v_0{}^2,$$

$$v_A{}^2 = v_0{}^2 - 2gy_A \quad\Rightarrow\quad v^2 + 2gy_A = v_0{}^2.$$

We equate the two expressions that each equal $v_0{}^2$ and obtain

$$\tfrac{1}{4}v^2 + 2gy_A + 6g = v^2 + 2gy_A \;\Rightarrow\; 6g = \tfrac{3}{4}v^2,$$

which yields $v = (8g)^{1/2} = 8.85\,\text{m/s}$. (**b**) An object moving *upward* at A with speed $v = 8.85$ m/s will reach a maximum height $y - y_A = v^2/2g = 4.00\,\text{m}$ above point A (this is again a consequence of Eq.2-16, now with the "final" velocity set to zero to indicate the highest point). Thus, the top of its motion is 1.00 m above point B.

111.• There is no air resistance, which makes it quite accurate to set $a = -g = -9.8\,\text{m/s}^2$ (where *downward* is the $-y$ direction) for the duration of the fall. We are allowed to use Table 2-1 (replacing x by y) because this is *constant* acceleration motion; in fact, when the acceleration changes (during the process of catching the ball) we will again assume constant acceleration conditions; in this case, we have $a_2 = 25\,g = 245\,\text{m/s}^2$. (**a**) The time of fall is given by Eq.2-15 with $v_0 = 0$ and $y = 0$. Thus,

$$t = \sqrt{2y_0/g} = \sqrt{2(145)/9.8} = 5.44\ \text{(s)}.$$

(**b**) The final velocity for its free-fall (which becomes the initial velocity during the catching process) is found from Eq.2-16 [other eqs. can be used but they would use the result from part (a)].

$$v = -\sqrt{v_0^2 - 2g(y - y_0)} = -\sqrt{2g\,y_0} = -53.3\ \text{(m/s)}.$$

where the negative root is chosen since this is a *downward* velocity. Thus, the speed is $|v| = 53.3\,\text{m/s}$. (**c**) For the catching process, the answer to part (b) plays the role of an *initial* velocity ($v_0 = -53.3\,\text{m/s}$) and the final velocity must become zero. Using Eq. 2-16, we find

$$\Delta y_2 = \frac{v^2 - v_0^2}{2a_2} = \frac{0 - (-53.3)^2}{2(245)} = -5.80\ \text{(m)},$$

where the negative value of Δy_2 signifies that the distance traveled while arresting its motion is *downward*.

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

***Ex.*2-1**, ***Prob.*2-71** & ***Ex.*2-2**, ***Prob.*2-88**.

112.• We neglect air resistance, which justifies setting $a = -g = -9.8\,\text{m/s}^2$ (taking *down* as the $-y$ direction) for the duration of the motion. We are allowed to use Table 2-1 (replacing x by y) because this is *constant* acceleration motion. The ground level is taken to correspond to $y = 0$. (**a**) With $y_0 = h$ and v_0 replaced with $-v_0$, Eq.2-16 leads to

$$v = \sqrt{(-v_0)^2 - 2g\,(y - y_0)} = \sqrt{v_0^2 + 2gh}\,.$$

The positive root is taken because the problem asks for the speed (the *magnitude* of the velocity). (**b**) We use the quadratic formula to solve Eq.2-15 for t, with v_0 replaced with $-v_0$,

$$\Delta y = -v_0\,t - \frac{1}{2}gt^2 \Rightarrow t = \frac{1}{g}\,(-v_0 + \sqrt{(-v_0)^2 - 2g\Delta y}\,).$$

where the positive root is chosen to yield $t > 0$. With $y = 0$ and $y_0 = h$, this becomes

$$t = \frac{1}{g}\,(\sqrt{v_0^2 + 2gh} - v_0).$$

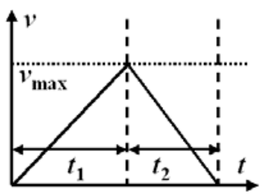
(**c**) If it were thrown *upward* with that speed from height h then (in the absence of air friction) it would return to height h with that same *downward* speed and would therefore yield the same final speed (before hitting the ground) as in part (a). (**d**) Having to travel up before it starts its descent certainly requires more time than in part (b). The calculation is quite similar, however, except for now having $+v_0$ in the equation where we had put in $-v_0$ in part (b). The details follow:

$$\Delta y = v_0\,t - \frac{1}{2}gt^2 \Rightarrow t = \frac{1}{g}\,(v_0 + \sqrt{v_0^2 - 2g\Delta y}\,).$$

with the positive root again chosen to yield $t > 0$. With $y = 0$ and $y_0 = h$, we obtain

$$t = \frac{1}{g}\,(v_0 + \sqrt{v_0^2 + 2gh}\,).$$

挑戰題〉設直線賽車比賽總長為 S, 若跑車前段加速 ($a_1 > 0$),而後段減速($-a_2 < 0$), 試計算跑車所花時間。



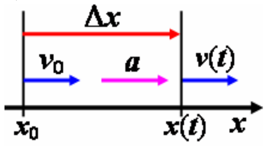
Sol. Let the distance during the period t_1 of the acceleration a_1 be S_1 and the distance during the period t_2 of the acceleration $-a_2$ be S_2. The maximum speed of car is $v_{max}{}^2 = 2a_1S_1 = 2a_2S_2$. From $S = S_1 + S_2$, we have $S_1 = \dfrac{a_2S}{a_1 + a_2} = \dfrac{1}{2}a_1t_1{}^2$ and $S_2 = \dfrac{a_1S}{a_1 + a_2} = \dfrac{1}{2}a_2t_2{}^2$.

Solve them to find $t_1 = [\dfrac{2a_2S}{a_1(a_1 + a_2)}]^{1/2}$ and $t_2 = [\dfrac{2a_1S}{a_2(a_1 + a_2)}]^{1/2}$, so $\Delta t = t_1 + t_2 = [\dfrac{2(a_1 + a_2)S}{a_1a_2}]^{1/2}$.

Using $S = 0.25\,\text{mi} = 1320\,\text{ft}$, $a_1 = 24\,\text{ft/s}^2$, and $a_2 = -32\,\text{ft/s}^2$ leads to $\Delta t = 13.9$ s.

重點整理－第 2 章　直線運動

宇宙萬物皆在動，但如何動？力學包含**運動學**與**動力學**；運動學是力學之初步。**運動學**旨在探討物體如何運動，即描述物體在空間的位置 $\mathbf{r}$ 與時間 t 之關係，$\mathbf{r} = \mathbf{r}(t)$；只用“**空間**”及“**時間**”兩基本概念，無“**力**”與“**質量**”等概念。**動力學**：探討運動之起因，物體為什麼作這樣運動。即研討力、質點(或物體)以及運動物體之間的關係，或物體運動時所遵守的定律或法則－**牛頓運動定律**。



一維或直線運動 $x = x(t)$,

時間 $t_1 \to 0 \Rightarrow t_2 \to t$,

時距 $\Delta t \equiv t_2 - t_1 \to t$,

初位置 $x_1 \equiv x(t_1) \to x_0 \Rightarrow$ 末位置 $x_2 \equiv x(t_2) \to x$,

位移為“位置之改變量” $\Delta x \equiv x_2 - x_1 \to x - x_0$,

只與初位置及末位置有關，但與運動細節無關.

平均速度為“單位時間之位移” $v_{av} \equiv \Delta x/\Delta t$,

(瞬時)**速度**為位置之時變率 $v = dx/dt$,

速率指(a)速度大小或(b)運動總路程除以時距

初速度 $v_1 \equiv v(t_1) \to v_0 \Rightarrow$ 末速度 $v_2 \equiv v(t_2) \to v$;

速度改變量 $\Delta v \equiv v_2 - v_1 \to v - v_0$,

平均加速度為單位時間之速度改變量 $a_{av} \equiv \Delta v/\Delta t$,

(瞬時)**加速度**為速度之時變率 $a = dv/dt = d^2x/dt^2$,

一維等加速度運動 $a = a_{av} = \text{const.}$,

$v_{av} = \frac{1}{2}(v_0 + v)$，即‘**初速度**’與‘**末速度**’之平均值,

$\Delta v = a\Delta t = a\,t$ or $v = v_0 + a\,t$,

$\Delta x = v_{av}\Delta t = v_0\,t + \frac{1}{2}a\,t^2$, or $x = x_0 + v_0 t + \frac{1}{2}at^2$,

$v^2 - v_0^2 = 2a\Delta x$, or $v^2 = v_0^2 + 2a(x - x_0)$,

Note $v = 0$ 表示運動停止或運動方向即將改變(即前後速度變號)，該點為**折返點**;

自由下落運動：設鉛直方向之加速度為定值

$x \to y$ and $a \to a_y = -g$ ($\Delta y > 0$: up),

地表自由下落加速度 $g = 9.8\ \text{m/s}^2 = 49/5\ \text{m/s}^2$.

•地震時地表加速度以 gal 表示，1 gal = 1 cm/s^2.

•人類跑百米最快需 9.69 s (2009 柏林,牙買加柏特)

•據調查人與人之距離約 5~6 人. •頸骨受傷/鞭樣損傷：是車禍常見的症狀，主要因為車禍發生時，頭部及頸部的脊骨就如鞭子鞭動一樣，因突然而來的劇動而受傷。 •基隆之 $g = 9.78974\ \text{m/s}^2$。

Why can a woodpecker survive the severe impacts with a tree limb?

為何啄木鳥激烈的撞擊大樹枝還能存活？

解題策略: **1.問題**瞭解嘛？**2.單位**正確嘛？**3.答案**合理嘛？**4.讀懂圖形**。Note $d(x^n)/dx = nx^{n-1}$.

Q.某質點在某時刻的速度為+18 m/s, 2.4 s 後速率變為 30 m/s 但往相反的方向. 則在 2.4 s 內的平均加速度為 (a) +10 m/s^2; (b) +20 m/s^2; (c) −10 m/s^2; (d) −20 m/s^2. ***Q.***車速為 180 km/h 之車子突然煞車，若煞車距離為 175 m，試計算煞車過程之加速度. (*Ans.* −7.14 m/s^2) ***Q.***設地表附近 $g = 9.80\ \text{m/s}^2$，某球於離地 33.6 m 高處，以速率 35.0 m/s 鉛直上拋，試計算該球可抵達之最大高度(a)及於空中停留時間(b). [*Ans.* (62.5+33.6) m & 8.00 s]

motion,運動; kinematics,運動學; particle,質點; position 位置; origin/zero point,原點; positive/negative direction, 正/負的方向; axis (座標)軸; coordinate,座標; vector,向量; displacement,位移; distance,距離; total distance,總距離/路程; time interval,時距; travel,行進; slope,斜率; average velocity,平均速度; (instantaneous) velocity,(瞬時)速度; speed,速率; speedometer,速率錶; average acceleration,平均加速度; (instantaneous) acceleration (瞬時)加速度; constant acceleration,等加速度, free-fall,自由下落; derivative,導數/微商; tectonic plate,板塊; artery,動脈; whiplash injury,頸部扭傷; head restraint,頭枕; woodpecker,啄木鳥; beak,鳥啄; rat-tat,咚咚的聲音,敲擊聲; fanatical,狂熱的/入迷的; armadillo,犰狳(中南美產); beat-up,用壞了的; pickup 臨時湊成的/偶然認識的; sprinter,短跑選手; energy conservation (*EC*); Niagara Falls,尼加拉瓜瀑布; Porche,保時捷; NASCAR: National Association of Stock Car Auto Racing,全國運動汽車競賽協會; jai alai,回力球(類似手球的室內遊戲,盛行於拉丁美洲) •1 knot = 1.852 km/h

•高速鐵路是指行車時速達二百公里以上的行車系統(電車)，台灣高鐵((960105 營運通車)之新幹線電車平均行車速率 230 km/h (63.9 m/s)，最高時速 300 km/h，台北至高雄左營距 345 km，行車需 90 分.

•世上最快電車—法國 TGV 最高時速可達 574.8 km (357.2 英里)，而上海磁浮車時速達 435 km. •1971 (美)阿波羅**十五**號太空人在月球表面，左手持**鐵錘**，右手拿**羽毛**，同時釋放，結果鐵錘與羽毛同時著地。

J1.“交通與物理”，黃定維及黃偉能，物理雙月刊，24 卷 2 期(2004 年 4 月) 334-337。**J2**. “***The evolution of transport***”, J. H. Ausubel and C. Marchetti, *The Industrial Physicist*, April/May 2001, pp. 20-24。