9. (1) $\overline{OC}=1\,\text{m}$，故彈簧自由長度 $=1-0.3=0.7$ m

$\overline{OB}=1\cos 45°=0.7071\,\text{m}$，此時彈簧伸長量為 0.0071 m

彈性功 + 重力功 = 位能差

$$\frac{1}{2}(500)(0.3)^2-\frac{1}{2}(500)(0.0071)^2+2(9.81)(0.5)=\frac{1}{2}(2)(v_B^2)$$

$\Rightarrow v_B=5.7$ m/s

(2) $2(9.81)(1)=\frac{1}{2}(2)v_A^2$

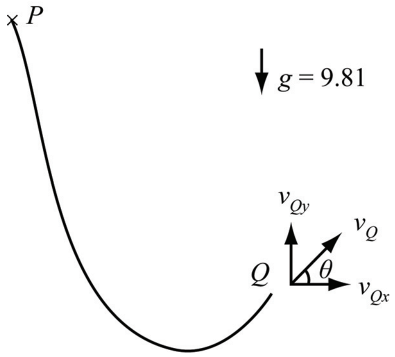
$v_A=4.43$ m/s

10. 設前行距離為 $x$ m

$$\frac{1}{2}(1500)(0.65)^2+\frac{1}{2}(15)(10)^2=(0.2)(15)(9.81)(2.5+x)+\frac{1}{2}(1500)(0.63+x)^2$$

解上式得 $x=0.5$ m

11. $y_P=3(-3)^2=27$ m




$y_Q=3(1)^2=3$ m

$\therefore m(9.81)(27-3)=\frac{1}{2}mv_Q^2$

$\Rightarrow v_Q=21.7$ m/s

$\left.\frac{dy}{dx}\right|_{x=1}=6=\tan\theta, v_{Qx}=3.57$ m/s

$\Rightarrow \theta=80.54°, v_{Qy}=21.4$ m/s

離開 $Q$ 後繼續往上飛 $t_1$ s

$t_1=\frac{21.4}{9.81}=2.181\,\text{s}$

回落到點 $Q$ 之高度共花了 $2t\,\text{s}=4.363\,\text{s}$

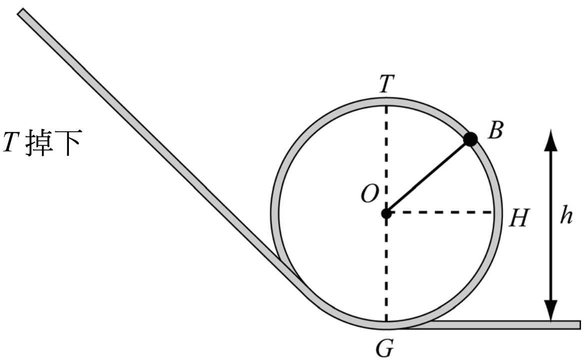
如繼續用了 $t$ s 從 $Q$ 落到 $y=0$ 位置，則

$3=21.4t+\frac{1}{2}(9.81)t^2\Rightarrow t=0.136\,\text{s}$

所以，$R$ 之 $x$ 座標 $=3.57(4.363+0.136)+1=17.06$

12. (1) 當球來到任一高度 $h$ 的點 $B$ 時，其速度 $v_B$：

$mg(L-h)=\frac{1}{2}mv_B^2\Rightarrow v_B^2=2g(L-h)$




其離心力 $=m\frac{v_B^2}{r}=\frac{4mg(L-h)}{d}$

此離心力最小要為 $mg$，才不致在最高點 $T$ 掉下

$\therefore mg=\frac{4mg(L-d)}{d}\Rightarrow L=\frac{5}{4}d$ m

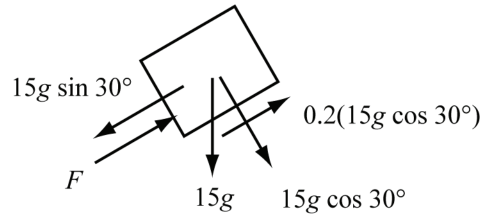
(2) 在 $H$ 點，$v_H=2g\left(L-\frac{d}{2}\right)$

$$\text{軌道反作用力 = 離心力}=\frac{4mg\left(L-\frac{d}{2}\right)}{d}=\frac{2mg(2L-d)}{d}\,\text{N}$$

13. $F = 15g\sin 30° + (0.2)(15g\cos 30°) = 99.1\text{ N}$

所以，其功率 $= Fv = 495.3\text{ W}$

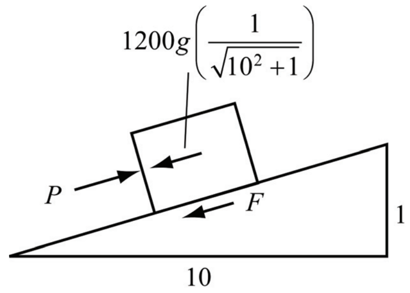
機械效率 $= \dfrac{(15g\sin 30°)(5)}{495.3} \times 100\% = 74\%$




14. 車行之阻力 $F$： $F\left(\dfrac{40\times 10^3}{3600}\right) = 3300 \Rightarrow F = 297\text{ N}$

$P = 1200g\left(\dfrac{1}{\sqrt{10^2+1}}\right) + F = 1468.4\text{ N}$

$\therefore Pv = 3300 \Rightarrow v = 2.25\text{ m/s} = 8.1\text{ km/hr}$



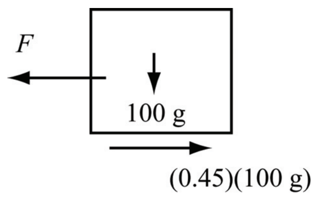

15. 功率 $= (1100-950)(9.81)(0.5) = 735.75\text{ W}$

16. $v^2 = v_0^2 + 2as \Rightarrow 3^2 = 0^2 + 2a(15) \Rightarrow a = 0.3\text{ m/s}^2$

$F - 0.45(100g) = 100(0.3) \Rightarrow F = 471.45$

所以，輸出功率 $= Fv = (471.45)(3) = 1414.4\text{ W}$

$\Rightarrow$ 輸入功率 $= \dfrac{1414.4}{0.75} = 1886\text{ W}$




17. 當套筒自 $\theta = 90°$ 狀態滑下至某 $\theta$

彈簧伸長量 $= \dfrac{1.5}{\cos\theta} - 1.5 = (1.5)\left(\dfrac{1-\cos\theta}{\cos\theta}\right)$

$$v(\theta) = -20g(1.5\tan\theta) + \frac{1}{2}k(1.5)^2\left(\frac{1-\cos\theta}{\cos\theta}\right)^2$$

$$= -294.3\tan\theta + 1.125k\left(\frac{1-\cos\theta}{\cos\theta}\right)^2$$

$v(50°) = 0 = -350.73 + 0.347k \Rightarrow k = 1009.5\text{ N/m}$

18. 由伸長量 $x_1$ 到 $x_2$ 彈簧力所作功

$$U_{1\to 2} = \int_{x_1}^{x_2} -(ax+bx^2)dx = -\left(\frac{ax^2}{2}+\frac{bx^3}{3}\right)\Bigg]_{x_1}^{x_2} = \left(\frac{ax_1^2}{2}+\frac{bx_1^3}{3}\right) - \left(\frac{ax_2^2}{2}+\frac{bx_2^3}{3}\right)$$

$$\therefore v_e = \frac{ax^2}{2} + \frac{bx^3}{3}$$

19. $U_{0\to 1} = mgR^2\left(\dfrac{1}{r_1} - \dfrac{1}{r_0}\right)$

$$= m(9.81)(6370\times 10^3)^2\left[\frac{10^{-3}}{(6370+1300)} - \frac{10^{-3}}{(6370+400)}\right]$$

$$U_{0\to 1} = \frac{1}{2}mv_1^2 - \frac{1}{2}mv_0^2$$

$$\Rightarrow v_1^2 = \left(\frac{36000\times 10^3}{3600}\right)^2 + 2(9.81)(6370\times 10^3)^2\left[\frac{10^{-3}}{(6370+1300)} - \frac{10^{-3}}{(6370+400)}\right]$$

$\Rightarrow v_1 = 9284.5\text{ m/s} = 33424\text{ km/hr}$

20. $F_x = -\frac{\partial V}{\partial x} = -(10z + y)$

$F_y = -\frac{\partial V}{\partial y} = -(x + 15yz)$

$F_z = -\frac{\partial V}{\partial z} = -\left(10x + \frac{15y^2}{2}\right)$

$\boldsymbol{F} = -(10z + y)\boldsymbol{i} - (x + 15yz)\boldsymbol{j} - \left(10x + \frac{15}{2}y^2\right)\boldsymbol{k}$

21. $\frac{\partial F_x}{\partial y} = 0$

$\frac{\partial F_y}{\partial x} = 2 \neq \frac{\partial F_x}{\partial y}$

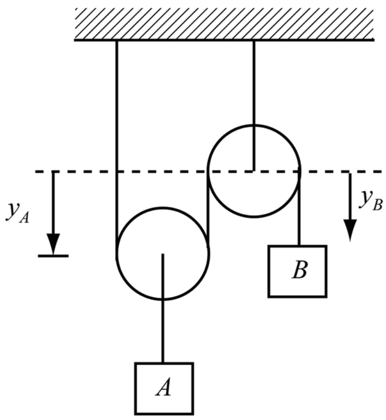
因此 $\boldsymbol{F}$ 不是保守力。

22. $U_{1\to 2} = \Delta T + \Delta V - F$

$180(2.5) = \frac{1}{2}(3+7+10)v^2 + 0 - (0.2)(3+7+10)g(2.5)$

$\Rightarrow v = 5.93 \text{ m/s}$

23. $2y_A + y_B =$ 常數




$\therefore 2\dot{y}_A + \dot{y}_B = 0 \Rightarrow 2\Delta y_A = -\Delta y_B$

$T_2 - T_1 = V_1 - V_2$

$\Rightarrow \frac{1}{2}(3+2)\dot{y}_A^2 + \frac{1}{2}(10)(\dot{y}_B)^2 - 0$

$= 10(9.81)(3) - (3+2)(9.81)(1.5)$

$\frac{45}{2}\dot{y}_A^2 = (22.5)(9.81)$

$\Rightarrow \dot{y}_A = 3.13 \text{ m/s} \uparrow$

$\dot{y}_B = 6.26 \text{ m/s} \downarrow$

24. $T_1 + V_1 - L = T_2 + V_2$

$\frac{1}{2}(15\times 10^{-3})(600)^2 - L = 0 + \frac{1}{2}(4500)(0.5)^2$

$\Rightarrow L = 2137.5 \text{ J}$

25. $x^2 + y^2 = 1 \Rightarrow 2x\dot{x} + 2y\dot{y} = 0 \Rightarrow \dot{x} = -\frac{y}{x}\dot{y}$

$T_1 + V_1 = T_2 + V_2$

(1) $y = 2x$ 時， $y = \frac{2}{\sqrt{5}}, x = \frac{1}{\sqrt{5}}$

$y = x$ 時， $y = \frac{1}{\sqrt{2}} = x$

$\therefore 0 + mg\left(\frac{2}{\sqrt{5}} - \frac{1}{\sqrt{2}}\right) = \frac{1}{2}m\dot{y}^2 + \frac{1}{2}m\dot{y}^2$

$\Rightarrow \dot{y} = 1.36 \text{ m/s} = \dot{x}$

(2) $y = 0, \therefore \dot{x} = 0$

$0 + mg\left(\frac{2}{\sqrt{5}}\right) = \frac{1}{2}m\dot{y}^2$

# 第 5 章

**計算題**

1. (1) 動量 $= mv_0 = 10(1) = 10\ \text{kgms}^{-1}$

   (2) 衝量 $= \int_0^{20} P dt = \frac{1}{2}(50)(20) = 500\ \text{N}\cdot\text{s}$

   (3) $mv_0 + \int_0^{20} P dt = mv_f \Rightarrow v_f = \frac{10+500}{10} = 51\ \text{m/s}$

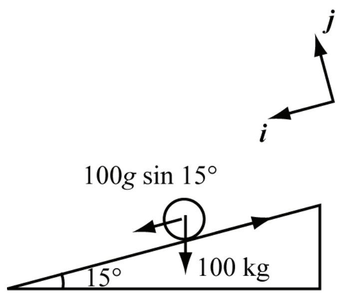
2. $20(3\boldsymbol{i}+4\boldsymbol{j}) + \int_0^5 (0.5t^2\boldsymbol{i} + 0.1t\boldsymbol{j})dt = 20\boldsymbol{v}_f \Rightarrow \boldsymbol{v}_f = (4\boldsymbol{i} + 4.1\boldsymbol{j})\ \text{m/s}$

3. $20\ \text{km/hr} \equiv 5.56\ \text{m/s}$

   $100(5.56) - \int_0^5 F dt = 0 \Rightarrow F = 111.1\ \text{N}$

4. 下坡 $\boldsymbol{i}$ 方向之動量 − 衝量原理

   $100(5.56) + \int_0^T (100g\sin 15° - 333.3) = 0 \Rightarrow T = 7\ \text{s}$



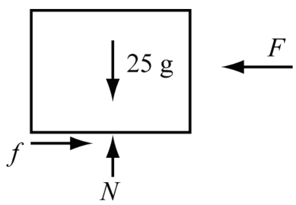

5. (1) 最大靜摩擦 $= 0.55(25g)\ \text{N} = 134.9\ \text{N}$
   所以方塊在 $F > 134.9\ \text{N}$ 才開始滑動，
   此時 $t = 8.1\ \text{s}$

   (2) 動摩擦力 $= 0.35(25g)\ \text{N} = 85.8\ \text{N}$
   所以，方塊在 24.85 s 後，施力小於動摩擦，方塊開始減速，
   所以方塊最高速發生在 24.8 s。
   動量衝量原理：

   $25(0) + \int_0^{24.85} F dt - \int_0^{8.1} 134.9 dt - \int_{8.1}^{24.85} 85.8 dt = 25v$

   $\frac{250(15)}{2} + \frac{250(9.85)}{2} - (134.9)(8.1) - 85.8(24.85 - 8.1) = 25v$

   $\Rightarrow v = 23.1\ \text{m/s}$




6. 最高速度：$F - R = 0 \Rightarrow v = \sqrt{\frac{F}{k}}$

   此時間內之動量衝量關係

   $m(0) + \int_0^T (F - kv^2)dt = mv$

   所以總衝量 $= \int_0^T (F - kv^2)dt = mv = m\sqrt{\frac{F}{k}}$

7. 水平方向動量衝量原理

   $10(5\cos 25°) = (10+20)v_f \Rightarrow v_f = 1.51\ \text{m/s}$

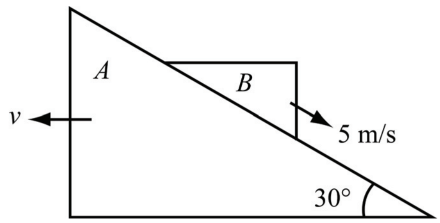
8. 設大三角之絕對速度為 $v$ 水平往左，

則 $B$ 之絕對速度為 $(5\cos 30° - v)$ ，

動量守恆：

$0 = 50v - 10(5\cos 30° - v)$

$\Rightarrow v = 0.72$ m/s




9. (1) $0 + F_{平均}(5) = 500\left(\dfrac{30\times 10^3}{3600}\right) \Rightarrow F_{平均} = 833.3$ N

(2) $500\left(\dfrac{30\times 10^3}{3600}\right) + 0 = (15500)v \Rightarrow v = 0.27$ m/s $\rightarrow$

船速同汽車往碼頭以 0.27 m/s 前進。

10. 運動學關係：

$v_N = 2v_M$

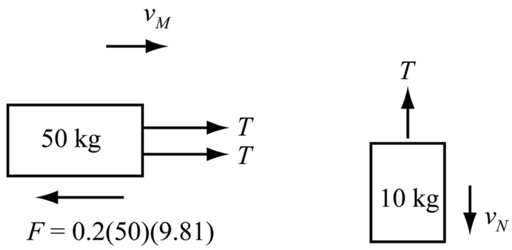
水平方向

$0 + [2T - 0.2(50)(9.81)]5 = 50v_M$ (i)

垂直方向

$0 + (10g - T)(5) = 10v_N$ (ii)

(i)&(ii) $\Rightarrow v_N = 10.9$ m/s




11. 嵌入後速度 $v$

$10(500) = 510(v) \Rightarrow v = 9.8039$ m/s

所以系統動能為

$\dfrac{1}{2}(0.51)(9.8039)^2 = 24.51$ J

系統首度靜止時木塊移動 $x$ m，則能量平衡

$\dfrac{1}{2}(1000)x^2 - 0.5(0.51)(9.81)(x) = 24.51$

$\Rightarrow x = 0.224$ m

12. 水平方向

$20(80) = 8(160)\cos\theta + 12(v)\cos 52°$

垂直方向

$8(160)\sin\theta - 12(v)\sin 52° = 0$

解上述二式得

$\theta = 47.7°$

$v = 100$ m/s

13. (1) 動量守恆

$4(4.5) + 1.5(-1.5) = 4(v_{Mf}) + 1.5(v_{Nf})$ (i)

$0.75 = -\dfrac{v_{Nf} - v_{Mf}}{-1.5 - 4.5}$ (ii)

(i) $\Rightarrow 4v_{Mf} + 1.5v_{Nf} = 15.75$ (iii)

(ii) $\Rightarrow v_{Nf} - v_{Mf} = +4.5$ (iv)

(iii)&(iv) $\Rightarrow v_{Mf} = 1.636$ m/s

$v_{Mf} = 1.636$ m/s

$v_{Nf} = 6.14$ m/s

(ii) 能量損失：

$$\frac{1}{2}4(4.5)^2+\frac{1}{2}(1.5)(1.5)^2-\frac{1}{2}(4)(1.636)^2-\frac{1}{2}(1.5)(6.14)^2=8.56\text{ J}$$

14. (1) 動量守恆

$4v_{Pi}+6(2)=6(5)+4v_{Pf}$ (i)

恢復係數

$0.5=\dfrac{v_{Pf}-5}{2-v_{Pi}}\Rightarrow 1-0.5v_{Pi}=v_{Pf}-5$ (ii)

(i)&(ii) $\Rightarrow v_{Pi}=7$ m/s

$v_{Pf}=2.5$ m/s

(2) $6(2)+F(0.003)=6(5)\Rightarrow F=6000$ N

15. 碰撞前相對速度 $v_i=\sqrt{2g(0.5)}$

碰撞後相對速度 $v_f=\sqrt{2g(0.078)}$

恢復係數 $=\dfrac{v_f}{v_i}=\sqrt{\dfrac{0.078}{0.5}}=0.395$

16. 撞擊前 $A$ 之速度： $v=\sqrt{2(9.81)(1)}=4.43$ m/s

動量守恆：$10(4.43)=20v_f\Rightarrow v_f=2.215$ m/s

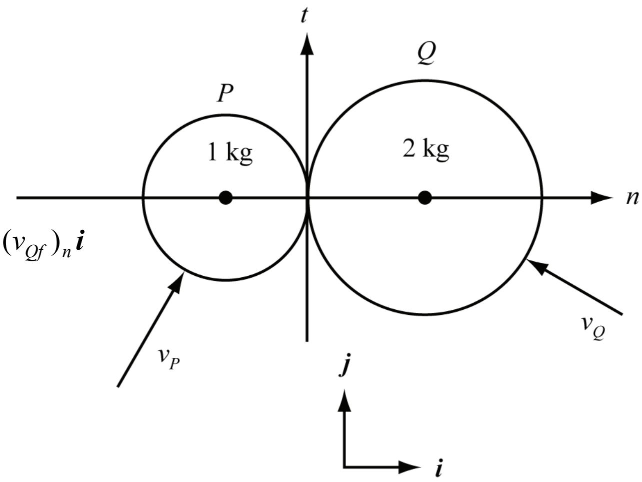
設壓縮量為 $h$，能量守恆

$$\frac{1}{2}(20)(2.215)^2+20(9.81)h=\frac{1}{2}(1000)h^2\Rightarrow h=0.566\text{ m}$$

17. 由 15 題知 $e=\sqrt{\dfrac{h_{n+1}}{h_n}}$

$\therefore \dfrac{h_1}{2}\dfrac{h_2}{h_1}=e^4\Rightarrow h_2=2(0.8)^4=0.82$ m

18. 碰撞前速度分量




$(v_P)_n=10\cos 60^\circ=5\boldsymbol{i}$ m/s

$(v_P)_t=10\sin 60^\circ=8.66\boldsymbol{j}$ m/s

$(v_Q)_n=-5\cos 30^\circ=-4.33\boldsymbol{i}$ m/s

$(v_Q)_t=5\sin 30^\circ=2.5\boldsymbol{j}$ m/s

碰撞後 $P$、$Q$ 在 $n$ 方向之速度分量為 $(v_{Pf})_n\boldsymbol{i}$ 及 $(v_{Qf})_n\boldsymbol{i}$

動量守恆：

$1(5)-2(4.33)=1(v_{Pf})_n+2(v_{Qf})_n$

$\Rightarrow (v_{Pf})_n+2(v_{Qf})_n=-3.66$ (i)

恢復係數

$0.8=\dfrac{(v_{Qf})_n-(v_{Pf})_n}{5-(-4.33)}$

$\Rightarrow (v_{Qf})_n-(v_{Pf})=7.464$ (ii)

(i)&(ii)

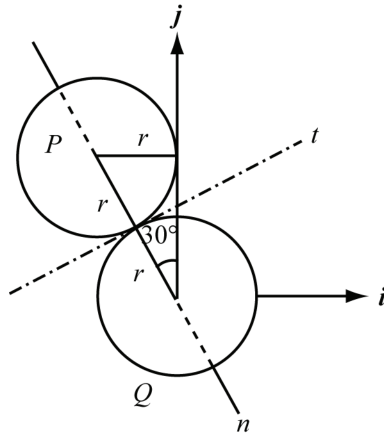
$(v_{Qf})_n=1.268$ m/s

$(v_{Pf})_n=-6.196$ m/s

$\therefore \boldsymbol{v}_{Pf}=(-6.2\boldsymbol{i}+8.66\boldsymbol{j})$ m/s

$\boldsymbol{v}_{Qf}=(1.27\boldsymbol{i}+2.5\boldsymbol{j})$ m/s

19. (1) 球 $P$ 在剛碰撞前之速度 $=\sqrt{2g}=4.43\ \text{m/s}\downarrow$




碰撞前後 $P$ 及 $Q$ 的速度分量

$(v_{Pi})_n = 4.43\cos 30° = 3.836\ \text{m/s}$

$(v_{Pi})_t = -4.43\sin 30° = -2.215\ \text{m/s}$

$(v_{Qi})_n = 0, \therefore (v_{Qi})_n = (v_{Qi})_t = 0$

因受繩子拘束，故

$(\boldsymbol{v}_{Qf}) = v_{Qf}\boldsymbol{i}$

$\therefore (v_{Qf})_n = v_{Qf}\sin 30° = 0.5v_{Qf}$

$(v_{Qf})_t = v_{Qf}\cos 30° = 0.866v_{Qf}$

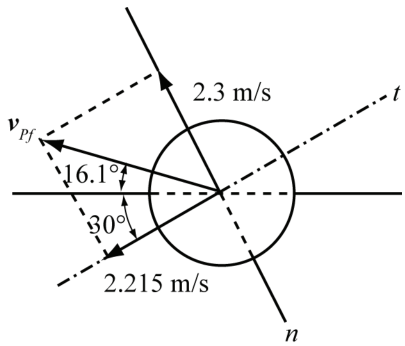
因為有繩子拘束，碰撞時會施力衝力，故動量不守恆。

球 $P$ 在 $t$ 方向無外加衝力

$(v_{Pi})_t = (v_{Pf})_t = -2.215\ \text{m/s}$

設 $\boldsymbol{T}$ 為繩子所施加之衝力，則球 $P$ 與 $Q$ 之動量衝量關係

$m\boldsymbol{v}_{Pi} + \cancel{m\boldsymbol{v}_{Qi}}^{\,0} + \boldsymbol{T}\Delta t = m\boldsymbol{v}_{Pf} + m\boldsymbol{v}_{Qf}$




$\boldsymbol{i}$ 方向

$0 = m(v_{Pf})_n\sin 30° + m(v_{Pf})_t\cos 30° + m(v_{Qf})$

$\Rightarrow 0 = 0.5(v_{Pf})_n - 1.918 + v_{Qf}$ (i)

因球為彈性，故恢復係數為 1

$\therefore (v_{Qf})_n - (v_{Pf})_n = (v_{Pi})_n - (v_{Qi})_n$

$0.5v_{Qf} = (v_{Pf})_n = 3.836 - 0$ (ii)

(i)&(ii) $\Rightarrow (v_{Pf})_n = -2.3\ \text{m/s}$

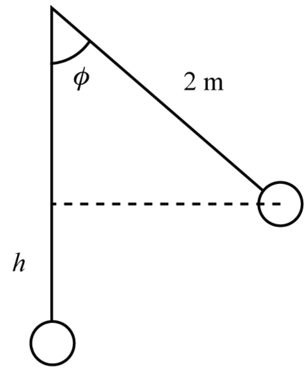
$v_{Qf} = 3.0688\ \text{m/s}$

所以，球 $P$ 碰撞後速度：

$v_{pf}^2 = (2.215)^2 + (2.3)^2$

$\Rightarrow v_{pf} = 3.19\ \text{m/s}$ 與水平成 16.1°

(2) 球 $Q$ 能量守恆：

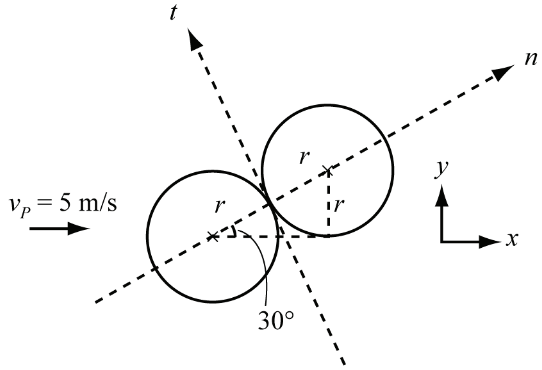



$$\frac{1}{2}m(v_{Qf})^2 = mgh$$

$$\Rightarrow h = \frac{(3.0688)^2}{2(9.81)} = 0.48\ \text{m}$$

$$\Rightarrow \phi = \cos^{-1}\frac{(2-0.48)}{2} = 40.5°$$

20. 撞擊前後之速度分量




$(v_{Pi})_n = 5\cos 30° = 4.33\ \text{m/s}$

$(v_{Pi})_t = 5\sin 30° = -2.5\ \text{m/s}$

$(v_{Qi})_n = (v_{Qi})_t = 0$

碰撞後

$(v_{Pf})_t = (v_{Pi})_t = -2.5\ \text{m/s}$

$(V_{Qf})_t = 0$

$n$ 方向碰撞前後動量守恆

$m(v_{Pi})_n + m(v_{Qi})_n = m(v_{Pf})_n + m(v_{Qf})_n$

$\Rightarrow 4.33 = (v_{Pf})_n + (v_{Qf})_n \qquad \text{(i)}$

球為彈性，所以

$(v_{Pi})_n - (v_{Qi})_n = (v_{Qf})_n - (v_{Pf})_n$

$\Rightarrow \qquad 4.33 = (v_{Qf})_n - (v_{Pf})_n$

$\Rightarrow \quad \therefore (v_{Qf})_n = 4.33 \text{ m/s}$

$(v_{Pf})_n = 0 \text{ m/s}$

$\therefore (v_{Qf})_x = 4.33\cos 30° = 3.75 \text{ m/s}$

$(v_{Qf})_y = 4.33\sin 30° = 2.165 \text{ m/s}$

$$\therefore x = 3.75\frac{(2)(2.165)}{g} = 1.655 \text{ m}$$

21. (1) 系統的總動量 $\sum_{i=1}^{3} \boldsymbol{L}_i$

$$\sum_{i=1}^{3} \boldsymbol{L}_i = 3(9\boldsymbol{i}) + 5(4\boldsymbol{j} + 5\boldsymbol{k}) + 6(3\boldsymbol{i} + 7\boldsymbol{k})$$

$$= (45\boldsymbol{i} + 20\boldsymbol{j} + 67\boldsymbol{k}) \text{ kgms}^{-1}$$

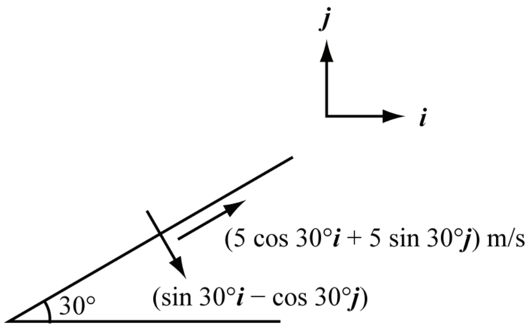
(2) 總角動量 $\sum_{i=1}^{3} \boldsymbol{H}_{oi}$

$$\sum_{i=1}^{3} \boldsymbol{H}_{oi} = \sum_{i=1}^{3} \boldsymbol{r}_i \times m\boldsymbol{v}_i = (3\boldsymbol{i} + 3\boldsymbol{j}) \times 27\boldsymbol{i} + (2\boldsymbol{i} - \boldsymbol{j} + \boldsymbol{k}) \times (20\boldsymbol{j} + 25\boldsymbol{k}) + (\boldsymbol{i} + \boldsymbol{j} + \boldsymbol{k}) \times (18\boldsymbol{i} + 42\boldsymbol{k})$$

$$= -81\boldsymbol{k} - 45\boldsymbol{i} - 50\boldsymbol{j} + 40\boldsymbol{k} + 42\boldsymbol{i} - 24\boldsymbol{j} - 18\boldsymbol{k}$$

$$= (-3\boldsymbol{i} - 74\boldsymbol{j} - 59\boldsymbol{k}) \text{kgm}^2\text{s}^{-1}$$

22. (1) $A$ 之速度




$$\boldsymbol{v}_A = (5\cos 30°\boldsymbol{i} + 5\sin 30°\boldsymbol{j}) + (\sin 30°\boldsymbol{i} - \cos 30°\boldsymbol{j})$$

$$= (4.83\boldsymbol{i} + 1.63\boldsymbol{j}) \text{ m/s}$$

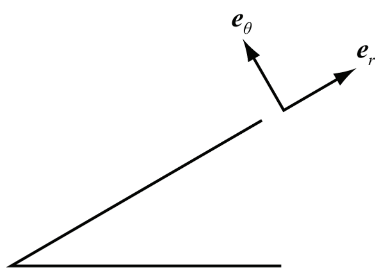
所以 $A$ 之動量 $= m\boldsymbol{v}_A = (9.66\boldsymbol{i} + 3.27\boldsymbol{j}) \text{ kgms}^{-1}$

(2) $\boldsymbol{H}_{OA} = \boldsymbol{r}_{OA} \times \boldsymbol{v}_A$

$$= (0.5\cos 30°\boldsymbol{i} + 0.5\sin 30\boldsymbol{j}) \times (4.83\boldsymbol{i} + 1.63\boldsymbol{j})$$

$$= -0.5\boldsymbol{k} \text{ kgm}^2\text{s}^{-1}$$

(3) $\dot{\boldsymbol{H}}_{OA} = \sum \boldsymbol{M}_O = \boldsymbol{r}_{OA} \times m\boldsymbol{a}_A$




$\boldsymbol{r}_{OA} = 0.5\boldsymbol{e}_r$

$\boldsymbol{a}_A = (\ddot{r} - r\dot{\theta}^2)\boldsymbol{e}_r + (r\ddot{\theta} + 2\dot{r}\dot{\theta})\boldsymbol{e}_\theta$

$$\therefore \sum \boldsymbol{M}_O = 0.5\boldsymbol{e}_r \times [(\ddot{r} - r\dot{\theta}^2)\boldsymbol{e}_r + (r\ddot{\theta} + 2\dot{r}\dot{\theta})\boldsymbol{e}_\theta]$$

$$= 0.5(r\ddot{\theta} + 2\dot{r}\dot{\theta})\boldsymbol{k}$$

$$= 0.5(0.5(0) + 2(5)(2)]\boldsymbol{k}$$

$$= 10\boldsymbol{k} \text{ N} \cdot \text{m}$$

$\therefore \dot{\boldsymbol{H}}_{OA} = 10\boldsymbol{k} \text{ N} \cdot \text{m}$