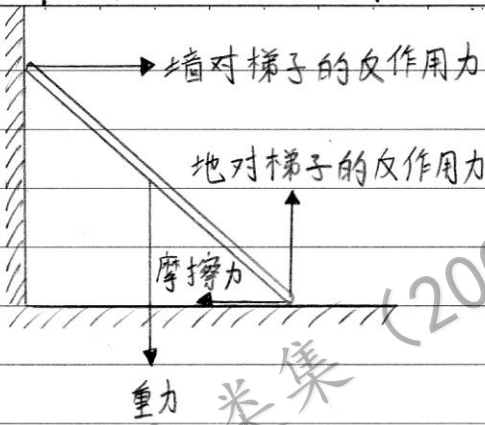


第五章：静力学。(2003年 - 2017年)。

①



D

设A点为转轴

$$\sum M = 0$$

$$-80 \times \frac{x}{2} \times \sin 36.87 + R \times \sin 53.13 = 0$$

$$R = 30N$$

$$\sum F_x = 0$$

$$f_k - R = 0$$

$$F_N \mu - 30 = 0$$

$$80\mu = 30$$

$$\mu = \frac{3}{8} \#$$

②

$$F = ma \quad F = ma$$

$$10 - mg\mu = 4m$$

$$8 - mg\mu = 2m$$

$$10 - 10m\mu = 4m$$

$$8 - 10m\mu = 2m$$

$$4m + 10m\mu = 10$$

$$4 - 5m\mu = m \quad \text{⑤} \quad C$$

$$m(2 + 5\mu) = 5$$

$$m = \frac{5}{2 + 5\mu} \quad \text{①}$$

Substitute ① into ②:

$$4 - 5\mu \left(\frac{5}{2 + 5\mu} \right) = \frac{5}{2 + 5\mu}$$

$$4 - \frac{25\mu}{2 + 5\mu} = \frac{5}{2 + 5\mu}$$

$$\frac{8 + 20\mu - 25\mu}{2 + 5\mu} = \frac{5}{2 + 5\mu}$$

$$8 - 5\mu = 5$$

$$\mu = 0.6$$

D

③

$$F + f_k = ma$$

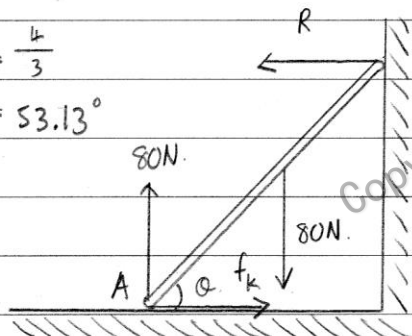
$$a = \frac{1}{m} F + \frac{f_k}{m}$$

A

④

$$\tan \theta = \frac{4}{3}$$

$$\theta = 53.13^\circ$$



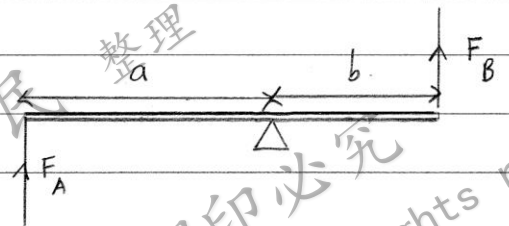
⑥

$$F_1 + F_2 + F_3 + F_4 + F_5 + F_6 = 0$$

$$F_1 + F_2 + F_3 + F_4 + F_5 = -F_6$$

$$= -2N \#$$

⑦



$$\sum M = 0$$

$$-F_A a + F_B b = 0$$

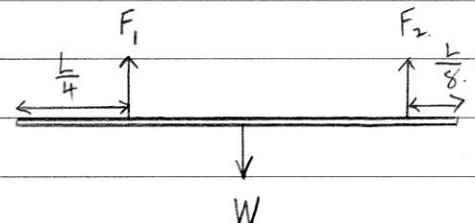
$$-k_A x_A a + k_B x_B b = 0$$

$$k_B x_B b = k_A x_A a$$

$$\frac{x_A}{x_B} = \frac{k_B b}{k_A a} \#$$

C

⑧



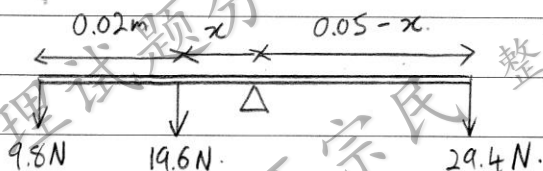
设重心, W 为转轴.

$$\begin{aligned} \Sigma M &= 0 \\ -F_1\left(\frac{L}{4}\right) + F_2\left(\frac{3L}{8}\right) &= 0 \\ F_2\left(\frac{3L}{8}\right) &= F_1\left(\frac{L}{4}\right) \\ \frac{F_2}{F_1} &= \frac{2}{3} \end{aligned}$$

B

9 C

10

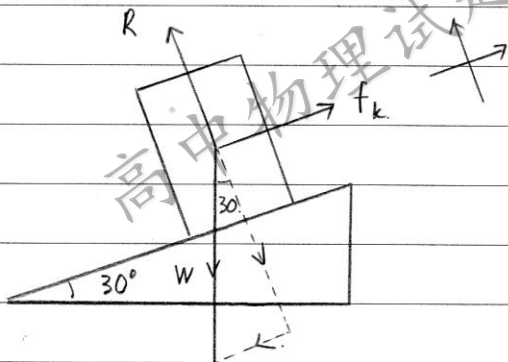


$$\begin{aligned} \Sigma M &= 0 \\ 9.8(0.02 + x) + 19.6x - 29.4(0.05 - x) &= 0 \\ 0.196 + 9.8x + 19.6x - 1.47 + 29.4x &= 0 \\ 58.8x &= 1.274 \\ x &= 0.0217 \end{aligned}$$

质心与 1 kg 的圆球间的距离 = $2.17 + 2 = 4.17 \text{ cm}$.

C

11

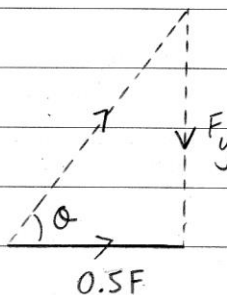


$$\begin{aligned} \Sigma F_x &= 0 \\ -W \sin 30 + f_k &= 0 \\ -W \sin 30 + F_N \mu &= 0 \\ -W \sin 30 + W \cos 30 \mu &= 0 \\ \mu W \cos 30 &= W \sin 30 \\ \mu &= \tan 30 \\ &= 0.577 \end{aligned}$$

为了让长方体静止在斜面上, 最小静摩擦系数至少要 0.577. 物体与斜面间的静摩擦系数为 0.8, 所以此物体将静止于斜面上

B

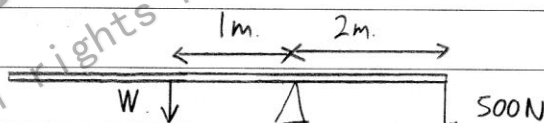
12



$$\begin{aligned} \tan \theta &= \frac{100}{10} \\ \frac{F_y}{0.5F} &= \frac{100}{10} \\ F_y &= 5F \end{aligned}$$

C

13

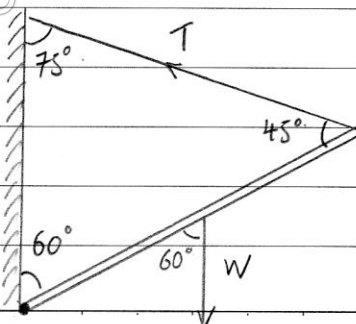


$$\begin{aligned} \Sigma M &= 0 \\ W(1) - 500(2) &= 0 \\ W &= 1000 \text{ N} \end{aligned}$$

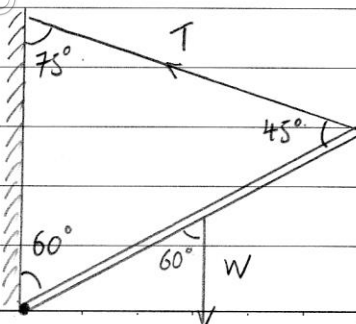
A.

14

15



16



$$\Sigma M = 0$$

$$-20 \times 0.6 \times \sin 60 + T \times 1.2 \times \sin 45 = 0$$

$$T = 12.2 \text{ N}$$

B

(17) 用假设法进行判断

• 若 A 和 B 的表面是光滑, 三个物体必定移动 (A 和 B 之间有摩擦力)

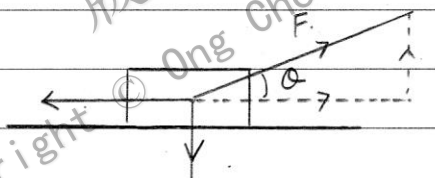
• 若 A 和桌面是光滑, 三个物体可静止 (A 和桌面无摩擦力)

B

(18) 墙对水管的反作用力、水管的重力和绳子的张力必定交错在同一个点上。

B

(19)



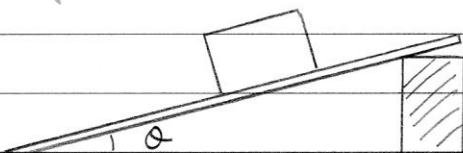
$$f_k = F_N \mu$$

$$= (mg - F \sin \theta) \mu$$

D

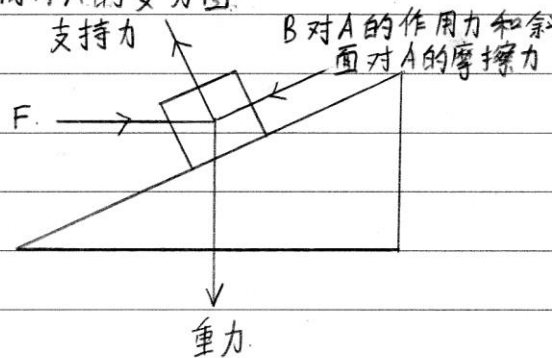
作答题

(1) (a).

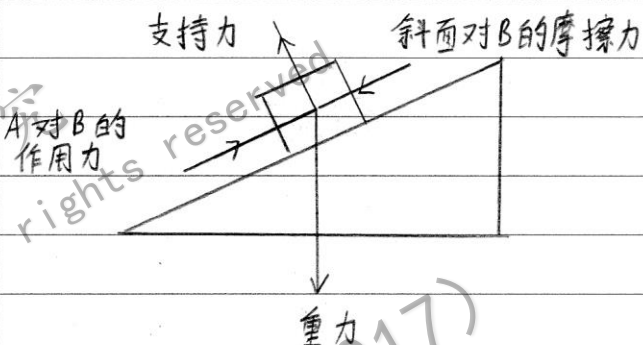


先将物块静置于一斜面上, 然后缓慢地增大斜面的倾角 θ 至某一值时, 物块便开始下滑。利用量角器量测 θ 角, 此即静摩擦角。

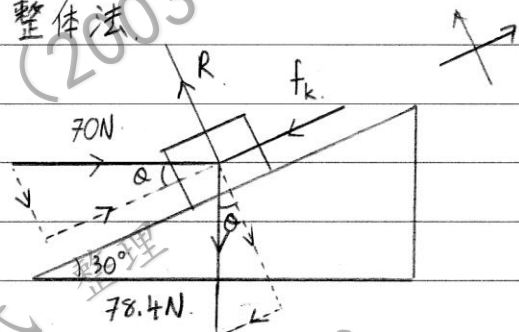
(b)(i) 物体 A 的受力图



物体 B 的受力图



(ii) 整体法



$$\Sigma F_y = 0$$

$$R - 70 \sin 30 - 78.4 \cos 30 = 0$$

$$R = 102.9 \text{ N}$$

$$F = ma$$

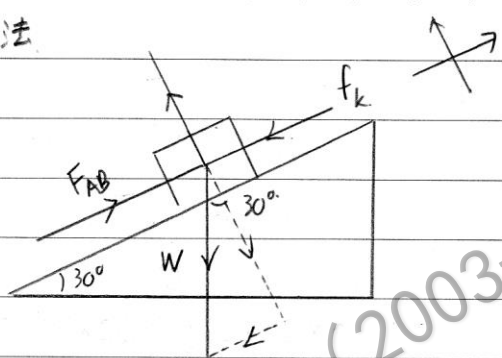
$$70 \cos 30 - 78.4 \sin 30 - f_k = 8a$$

$$70 \cos 30 - 78.4 \sin 30 - \mu R = 8a$$

$$70 \cos 30 - 78.4 \sin 30 - 0.2 \times 102.9 = 8a$$

$$a = 0.105 \text{ m/s}^2$$

(iii) 隔离法

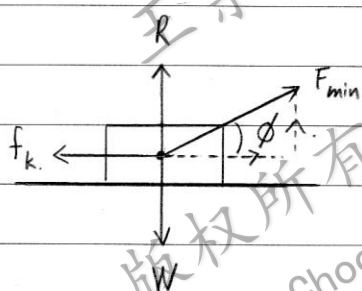


$$F_{AB} - W \sin \theta - f_k = ma$$

$$F_{AB} = 5 \times 9.8 \times \sin 30 - 5 \times 9.8 \times \cos 30 \times 0.2 = 5 \times 0.105$$

$$F_{AB} = 33.51 \text{ N}$$

② (a)



$$F = 0$$

$$F_{\min} \cos \phi - f_k = 0$$

$$F_{\min} \cos \phi - \mu(W - F_{\min} \sin \phi) = 0$$

$$F_{\min} \cos \phi - \mu mg + F_{\min} \mu \sin \phi = 0$$

$$F_{\min} (\cos \phi + \mu \sin \phi) = \mu mg$$

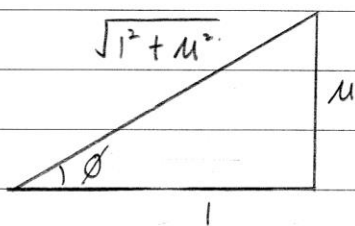
$$F_{\min} \left(\frac{1}{\sqrt{1+\mu^2}} + \mu \times \frac{\mu}{\sqrt{1+\mu^2}} \right) = \mu mg$$

$$F_{\min} \left(\frac{1+\mu^2}{\sqrt{1+\mu^2}} \right) = \mu mg$$

$$F_{\min} \left(\frac{1+\mu^2}{\sqrt{1+\mu^2}} \right) = \mu mg$$

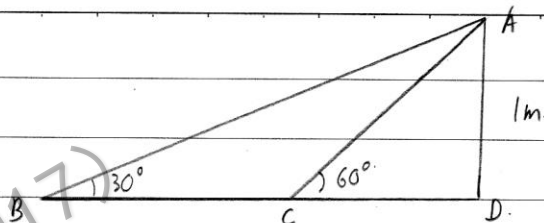
$$F_{\min} (\sqrt{1+\mu^2}) = \mu mg$$

$$F_{\min} = \frac{\mu mg}{\sqrt{1+\mu^2}}$$



$$\tan \phi = \mu$$

(b)



$$\tan 30 = \frac{1}{BD}$$

$$\tan 60 = \frac{1}{CD}$$

$$BD = 1.732 \text{ m}$$

$$CD = 0.577 \text{ m}$$

$$BC = BD - CD$$

$$= 1.732 \text{ m} - 0.577 \text{ m}$$

$$= 1.155 \text{ m}$$

$$\sin 30 = \frac{1}{AB}$$

$$\sin 60 = \frac{1}{AC}$$

$$AB = 2 \text{ m}$$

$$AC = 1.155 \text{ m}$$

绳子的长度 = $2 \text{ m} - 1.155 \text{ m}$

$$= 0.845 \text{ m}$$

$$F_s = \frac{1}{2} m v_B^2 + \mu F_N$$

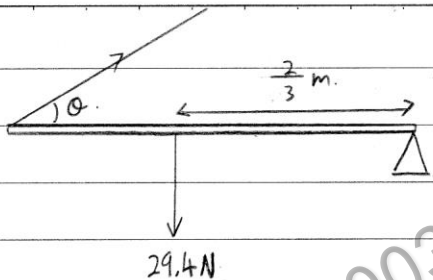
$$3 \times 0.845 = \frac{1}{2} \times 0.5 \times v_B^2 + 0.3$$

③ (i) $\Sigma F = 0$ 时, 物体原来若静止的, 保持静止状态; 若运动的, 将改成等速直线运动。

(ii) ΣF 恒定时, 物体将以恒定的加速度作变速运动。

④ (a) $\Sigma F = 0$ 和 $\Sigma M = 0$

(b)



$$\tan \theta = \frac{1}{2} L \div L$$

$$\theta = 26.565^\circ$$

$$T = 43.83 \text{ N}$$

$$F = kx$$

$$43.83 = k \left(\frac{1}{3} \right)$$

$$k = 87.65 \text{ N m}^{-1} \#$$

$$\Sigma M = 0$$

$$\Sigma F_y = 0$$

$$T \sin \theta - W = 0$$

$$T \sin 80.41 - 50 = 0$$

$$T = 50.71 \text{ N}$$

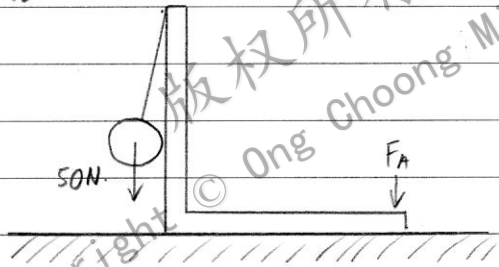
$$\Sigma F_x = 0$$

$$T \cos \theta - R = 0$$

$$50.71 \cos 80.41 - R = 0$$

$$R = 8.45 \text{ N}$$

(c) (i)



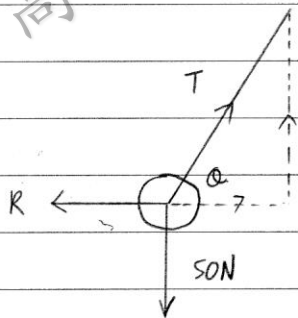
整体法

$$\Sigma M = 0$$

$$50 \times 0.2 - 2 \times F_A = 0$$

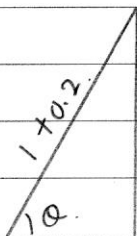
$$F_A = 5 \text{ N}$$

(ii)

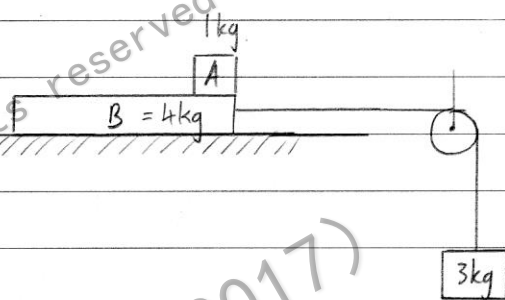


$$\cos \theta = \frac{0.2}{\sqrt{0.2^2 + 1^2}}$$

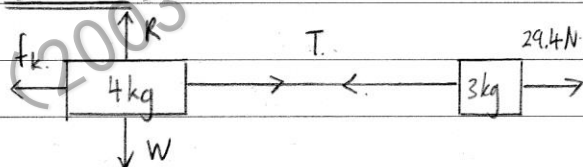
$$\theta = 80.41^\circ$$



(5) (a)



整体法



$$F = ma$$

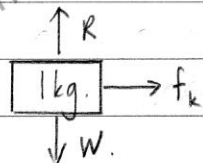
$$29.4 - f_k = (4+3)a_B$$

$$29.4 - \mu F_N = 7a_B$$

$$29.4 - 0.2 \times 1 \times 9.8 = 7a_B$$

$$a_B = 3.92 \text{ ms}^{-2} \#$$

隔离法



$$F = ma_A$$

$$f_k = ma_A$$

$$\mu F_N = ma_A$$

$$0.2 \times 1 \times 9.8 = 1a_A$$

$$a_A = 1.96 \text{ ms}^{-2} \#$$

(b) 物体 B

$$u = 0 \quad v^2 = u^2 + 2as.$$

$$v = ? \quad v^2 = 0 + 2 \times 3.92 \times 2$$

$$a = 3.92 \quad v = 3.96 \text{ ms}^{-1}$$

$$s = 2$$

$$t = ? \quad s = ut + \frac{1}{2}at^2$$

$$2 = 0 + \frac{1}{2} \times 3.92 t^2$$

$$t = 1.01 \text{ s.}$$

物体 A

$$u = 0 \quad v = u + at$$

$$t = 1.01 \quad = 0 + 1.96 \times 1.01$$

$$v = ? \quad = 1.98 \text{ ms}^{-1}$$

$$a = 1.96$$

$$s = ? \quad s = ut + \frac{1}{2}at^2$$

$$= 0 + \frac{1}{2} \times 1.96 \times 1.01^2$$

$$= 0.99 \text{ m}$$

A 与 B 的相对位移 = $2 \text{ m} - 1 \text{ m}$
 $= 1 \text{ m}$ #

(c) $f_k = \mu F_N$ $f_k = \mu F_N$
 $ma = \mu F_N$ $ma = \mu F_N$
 $1a = 0.2 \times 1 \times 9.8$ $4a = 0.2 \times 1 \times 9.8$
 $a = 1.96 \text{ ms}^{-2}$ $a = 0.49 \text{ ms}^{-2}$

物体 A

$$a = 1.96 \quad v^2 = u^2 + 2as.$$

$$u = 1.98 \quad 3.56^2 = 1.98^2 + 2 \times 1.96 \times s.$$

$$v = 3.56 \quad \therefore s = 2.23 \text{ m.}$$

$$s = ?$$

物体 B

$$a = -0.49 \quad v^2 = u^2 + 2as$$

$$u = 3.96 \quad 3.56^2 = 3.96^2 + 2 \times -0.49 \times s.$$

∴ 木板 B 的最短长度 = $3.07 \text{ m} - 2.23 \text{ m} + 1 \text{ m}$
 $= 1.84 \text{ m.}$

或

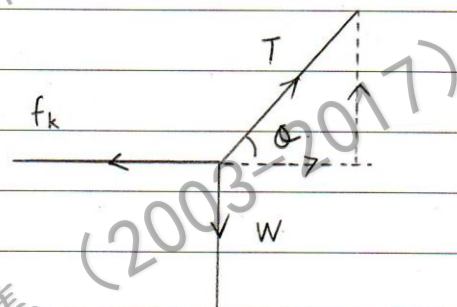
$$\frac{1}{2}m_A u_A^2 + \frac{1}{2}m_B u_B^2 = \frac{1}{2}(m_A + m_B)v^2 + f_k s.$$

$$\frac{1}{2} \times 1 \times 1.98^2 + \frac{1}{2} \times 4 \times 3.96^2 = \frac{1}{2}(1+4)3.56^2 + 0.2 \times 1 \times s$$

$$s = 0.84 \text{ m.}$$

∴ 木板 B 的最短长度 = $0.84 \text{ m} + 1 \text{ m}$
 $= 1.84 \text{ m.}$

⑥ (a) 该物体所受的合力及绕固定转轴的力距必须为零。



(b)

$$f_k = \mu F_N \quad f_k = T \cos \theta$$

$$= 0.3 \times 70 \times 10 \quad 210 = T \cos 37^\circ$$

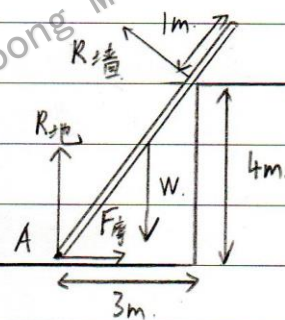
$$= 210 \text{ N} \quad T = 262.95 \text{ N.}$$

$$W = T \sin \theta$$

$$= 262.95 \times \sin 37^\circ$$

$$= 158.25 \text{ N.}$$

(c) (i)



$$\tan \theta = \frac{4}{3}$$

$$\theta = 53.13^\circ$$

设 A 点为转轴

$$\Sigma M = 0$$

$$-W \times \frac{x}{2} \times \sin(90-\theta) + R_{\text{墙}} \times \frac{5x}{6} = 0$$

$$-100 \times \frac{1}{2} \times \sin 36.87 + R_{\text{墙}} \times \frac{5}{6} = 0$$

$$R_{\text{墙}} = 36 \text{ N} \#$$

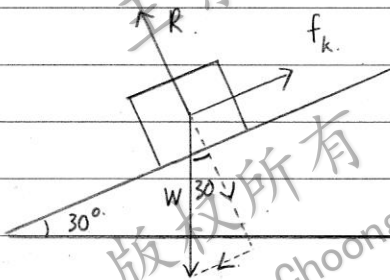
(ii) $\Sigma F_x = 0$

$$F_{\text{墙}} - R_{\text{墙}} \cos(90-\theta) = 0$$

$$F_{\text{墙}} = 36 \cos(90-53.13) = 0$$

$$F_{\text{墙}} = 28.8 \text{ N} \#$$

⑦ (a)



(b) $\Sigma F_x = 0$

$$mg \sin \theta - f_k = 0$$

$$5 \times 9.8 \sin 30 - f_k = 0$$

$$f_k = 24.5 \text{ N} \#$$

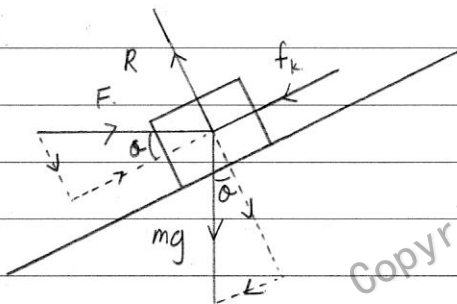
$$\mu F_N = 24.5 \text{ N}$$

$$\mu mg \cos \theta = 24.5 \text{ N}$$

$$\mu \times 5 \times 9.8 \times \cos 30 = 24.5$$

$$\mu = 0.577 \#$$

(c)



$$\Sigma F_y = 0$$

$$R - F \sin \theta - mg \cos \theta = 0$$

$$R - F \sin 30 - 5 \times 9.8 \times \cos 30 = 0$$

$$R = F \sin 30 + 42.435$$

$$\Sigma F_x = 0$$

$$F \cos \theta - mg \sin \theta - f_k = 0$$

$$F \cos \theta - mg \sin \theta - \mu R = 0$$

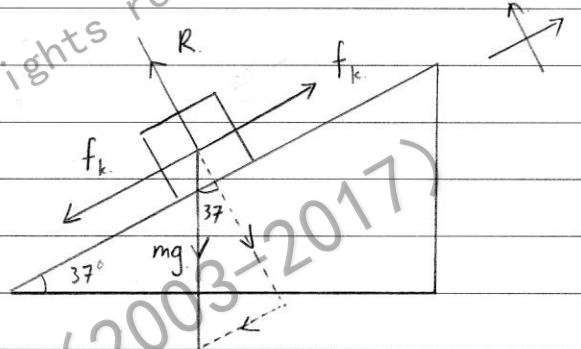
$$F \cos 30 - 5 \times 9.8 \sin 30 - 0.577(F \sin 30 + 42.435) = 0$$

$$0.5775F = 48.98$$

$$0.5775 \times 5a = 48.98$$

$$a = 16.96 \text{ ms}^{-2} \#$$

⑧ (i)



$$f_k = \mu F_N$$

$$= \mu mg \cos \theta$$

$$= 0.4 \times 2 \times 9.8 \times \cos 37$$

$$= 6.26 \text{ N}$$

上滑时的加速度

$$F = ma$$

$$f_k - mg \sin \theta = ma$$

$$6.26 - 2 \times 9.8 \sin 37 = 2a$$

$$a = -9.03 \text{ ms}^{-2}$$

下滑时的加速度

$$F = ma$$

$$f_k - mg \sin \theta = ma$$

$$6.26 - 2 \times 9.8 \sin 37 = 2a$$

$$a = -2.77 \text{ ms}^{-2}$$

(ii) 物体上滑

$$u = 10$$

$$v = u + at$$

$$v = 0$$

$$0 = 10 - 9.03t$$

$$t = ?$$

$$t = 1.107 \text{ s}$$

$$a = -9.03$$

$$s = ?$$

$$v^2 = u^2 + 2as$$

$$0 = 10^2 + 2(-9.03)s$$

$$s = 5.537 \text{ m}$$

物体下滑

$$u = 0$$

$$s = ut + \frac{1}{2}at^2$$

$$t = 0.893$$

$$s = 0 + \frac{1}{2} \times -2.77 \times 0.893^2$$

$$a = -2.77$$

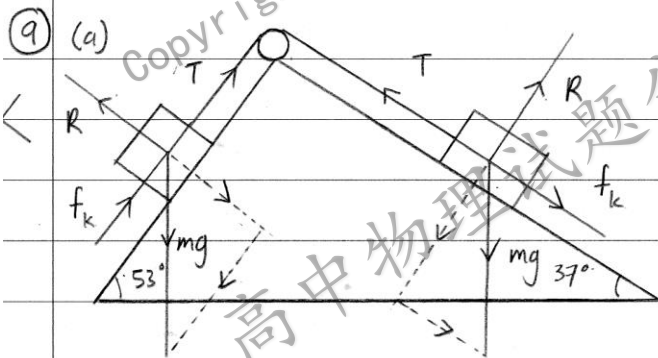
$$s = -1.104 \text{ m}$$

$$s = ?$$

∴ 物体前2秒内的净位移

$$= 5.537 \text{ m} - 1.104 \text{ m}$$

$$= 4.433 \text{ m} \#$$



(b) 整体法

$$F = ma$$

$$m_A g \sin \theta_1 - m_B g \sin \theta_2 - f_{kA} - f_{kB} = (m_A + m_B) a$$

$$m_A g \sin \theta_1 - m_B g \sin \theta_2 - m_A \mu \cos \theta_1 - m_B \mu \cos \theta_2 = (m_A + m_B) a$$

$$9.8 \sin 37 - 8 \times 9.8 \times 0.2 \cos 53 - 5 \times 9.8 \times 0.2 \cos 37 = (5 + 8) a$$

$$a = 1.22 \text{ ms}^{-2} \#$$

(c) $u = 0$

$$v^2 = u^2 + 2as$$

$$a = 1.22$$

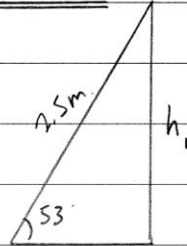
$$v^2 = 0^2 + 2 \times 1.22 \times 2.5$$

$$s = 2.5$$

$$v = 2.47 \text{ ms}^{-1} \#$$

$$v = ?$$

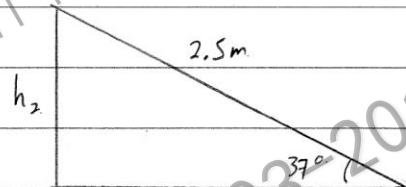
(d) 物块 A



$$h_1 = 2.5 \sin 53$$

$$= 1.997 \text{ m}$$

物块 B



$$h_2 = 2.5 \sin 37$$

$$= 1.505 \text{ m}$$

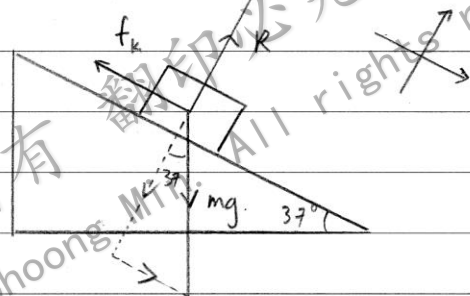
∴ 系统的总势能减少

$$= m_A g h_1 - m_B g h_2$$

$$= 8 \times 9.8 \times 1.997 - 5 \times 9.8 \times 1.505$$

$$= 82.84 \text{ J} \#$$

(10) (a)



$$F = ma$$

$$m g \sin \theta - f_k = ma$$

$$m g \sin \theta - m g \mu \cos \theta = ma$$

$$2 \times 10 \times \sin 37 - 2 \times 10 \times 0.3 \cos 37 = 2a$$

$$a = 3.62 \text{ ms}^{-2} \#$$

(b)

$$F = ma.$$

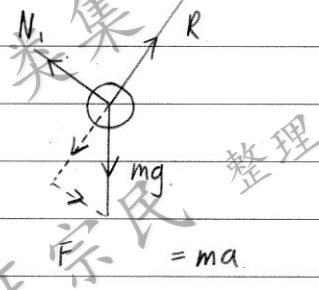
$$-f_k = ma.$$

$$-mg\mu = ma.$$

$$-2 \times 10 \times 0.3 = 2a$$

$$a = -3 \text{ ms}^{-2} \#$$

(c)



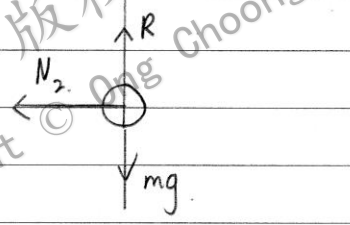
$$F = ma.$$

$$-mg \sin 37 + N_1 = ma.$$

$$-0.5 \times 10 \sin 37 + N_1 = 0.5 \times 3.62$$

$$N_1 = -1.2 \text{ N} \#$$

(d)



$$F = ma.$$

$$N_2 = 0.5 \times -3 = -1.5 \text{ N} \#$$

(e)

$$a = -3.62 \quad v^2 = u^2 + 2as.$$

$$u = 0 \quad v^2 = 0 + 2 \times 3.62 \times 3$$

$$s = 3 \quad v = 4.66 \text{ ms}^{-1} \#$$

$$v = ?$$

(f)

$$u = 4.66 \quad v^2 = u^2 + 2as.$$

$$a = -3 \quad 0 = 4.66^2 + 2(-3)s$$

$$s = ? \quad s = 3.62 \text{ m} \#$$

$$v = 0$$

(物体在 3 秒前已经停下)

(11) (a)

$$u = 0 \quad s = ut + \frac{1}{2}at^2$$

$$t = 2 \quad 4 = 0 + \frac{1}{2} \times a \times 2^2$$

$$s = 4 \quad a = 2 \text{ ms}^{-2} \#$$

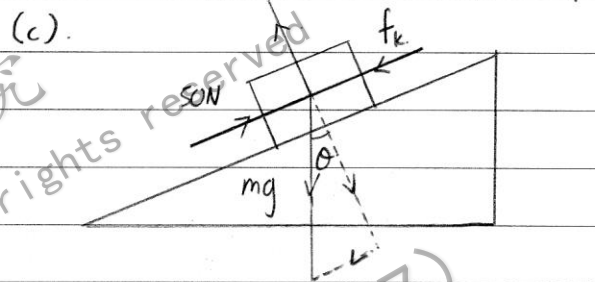
$$a = ?$$

(b)

$$s = \frac{1}{2}(u+v)t.$$

$$4 = \frac{1}{2}(0+v)2$$

$$v = 4 \text{ ms}^{-1} \#$$



$$F = ma.$$

$$50 - f_k - mg \sin \theta = ma.$$

$$50 - mg \mu \cos \theta - mg \sin \theta = ma.$$

$$50 - 5 \times 10 \times \mu \times 0.8 - 5 \times 10 \times 0.6 = 5 \times 2$$

$$\mu = 0.25 \#$$

(d)

$$F = ma.$$

$$-f_k - mg \sin \theta = ma.$$

$$-mg \mu \cos \theta - mg \sin \theta = ma.$$

$$-5 \times 10 \times 0.25 \times 0.8 - 5 \times 10 \times 0.6 = 5a.$$

$$a = -8 \text{ ms}^{-2} \#$$

(e)

$$u = 4 \quad v^2 = u^2 + 2as.$$

$$a = -8 \quad 0 = 4^2 + 2 \times -8s.$$

$$s = ? \quad s = 1 \text{ m} \#$$

$$v = 0$$

(f)

$$F = ma.$$

$$-mg \sin \theta + mg \mu \cos \theta = ma.$$

$$-5 \times 10 \times 0.6 + 5 \times 10 \times 0.25 \times 0.8 = 5a$$

$$a = -4 \text{ ms}^{-2} \#$$

$$a = -4$$

$$v^2 = u^2 + 2as$$

$$s = -5$$

$$v^2 = 0^2 + 2(-4)(-5)$$

$$u = 0$$

$$v = 6.32 \text{ ms}^{-2}$$

$$v = ?$$

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