Midterm Exam

HSE 207: Engineering Mechanics

Solutions

By Seungchul Lee

Problem 1 (5 points)

- Linear translation motion can be considered as a circular motion with the very large radius.
- Linear combination of circular motions can generate many different motions such as linear translation, ellipsoid, etc.

Problem 2 (10 points)

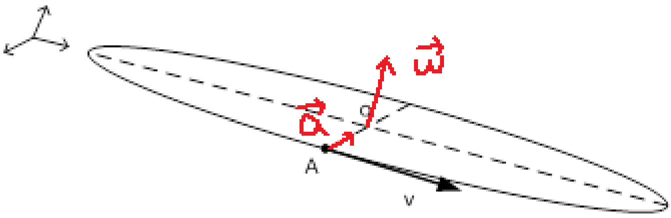
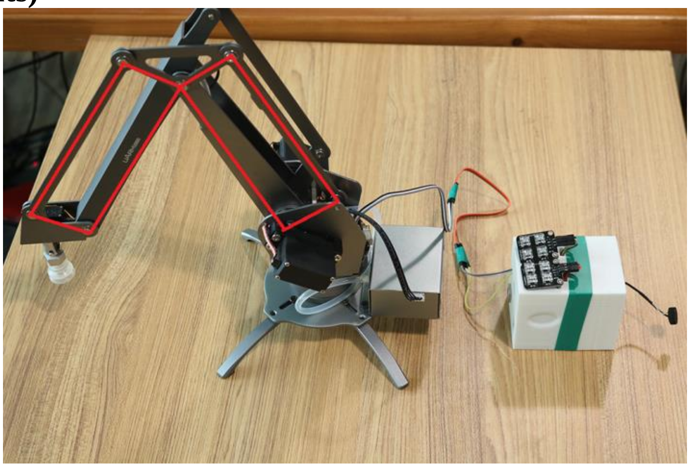


Figure 1

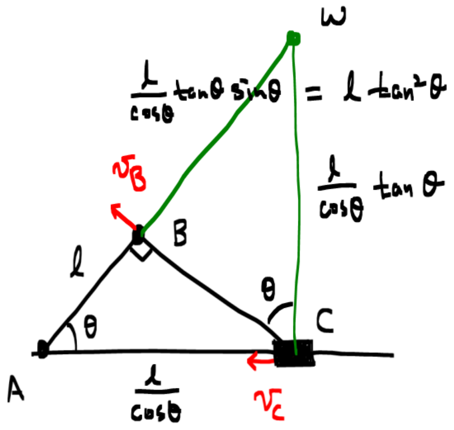
Problem 3 (5 points)

Problem 4 (10 points)



Problem 5 (5 points)
There are many cylinders in a car engine.

Problem 6 (10 points)



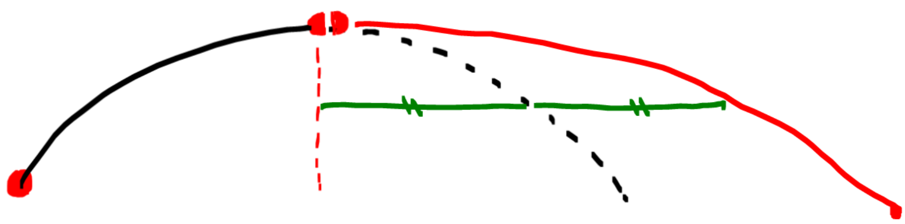
$$v_B = l\dot{\theta} = l\tan^2\theta\,\omega$$

$$\therefore \omega = \frac{\dot{\theta}}{\tan^2\theta}$$

$$\Rightarrow v_C = \frac{l}{\cos\theta}\tan\theta\cdot\omega$$

$$= \frac{l}{\sin\theta}\dot{\theta}$$

Problem 7 (10 points)

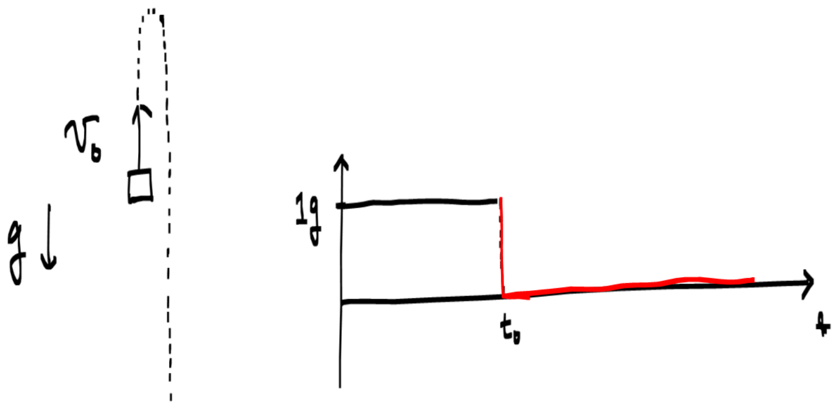


Problem 8 (10 points)
1) Inertia reference frame
2) Non-inertia reference frame

Problem 9 (10 points)
The same length = 0.1 m

Problem 10 (5 points)
Zero

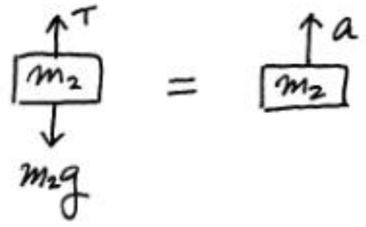
Problem 11 (10 points)



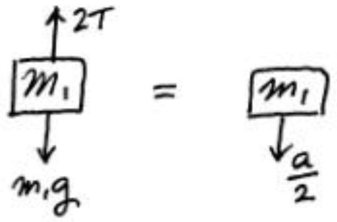
Problem 12 (20 points)

Problem 12.

(1)



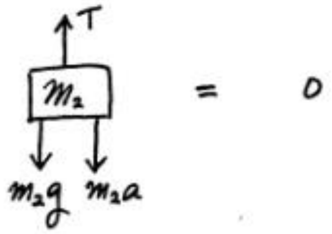
$$T - m_2 g = m_2 a$$



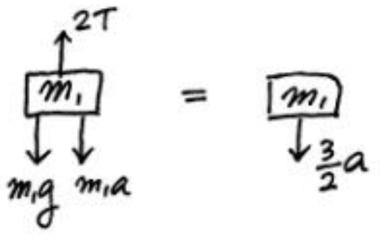
$$m_1 g - 2T = m_1 \cdot \frac{a}{2}$$

$$\therefore \ a = \frac{2m_1 - 4m_2}{m_1 + 4m_2} g$$

(2)



$$T - m_2 g - m_2 a = 0$$



$$m_1 g + m_1 a - 2T = \frac{3}{2} m_1 a$$

$$\therefore \ a = \frac{2m_1 - 4m_2}{m_1 + 4m_2} g$$

(3) weight of mass m_1 $= m_1 g - m_1 \cdot \frac{a}{2}$

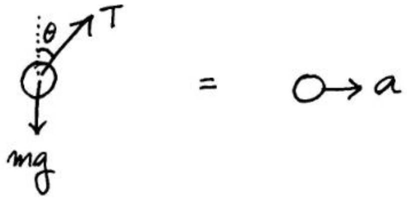
weight of mass m_2 $= m_2 g + m_2 a$.

Problem 13 (20 points)

problem 13.

1)

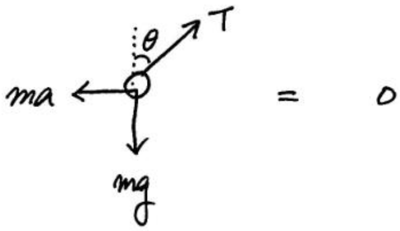
2)



$\Sigma F_x = ma$; $T\sin\theta = ma$.

$\Sigma F_y = 0$; $T\cos\theta - mg = 0$.

3)



$\Sigma F_x = 0$; $T\sin\theta - ma = 0$.

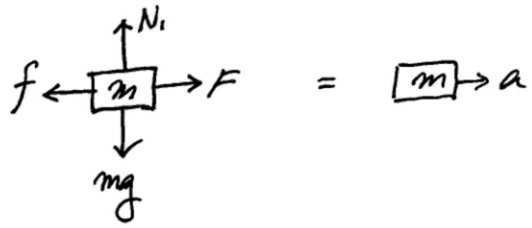
$\Sigma F_y = 0$; $T\cos\theta - mg = 0$.

4) weight of a ball $= T = \dfrac{ma}{\sin\theta} = \dfrac{ma}{\sin(\tan^{-1}(\frac{a}{g}))}$

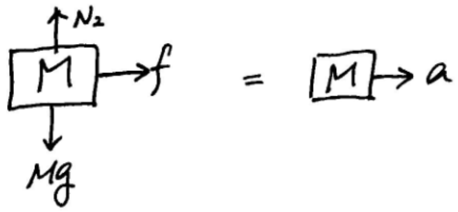
Problem 14 (10 points)

Problem 14.

1)



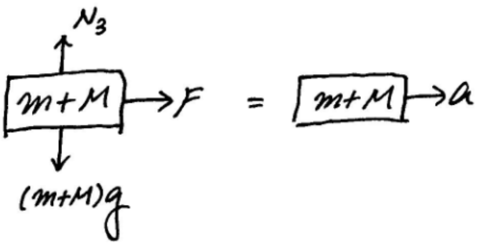
$F - f = ma.$



$f = Ma.$

$\therefore\ a = \dfrac{F}{m+M}.$

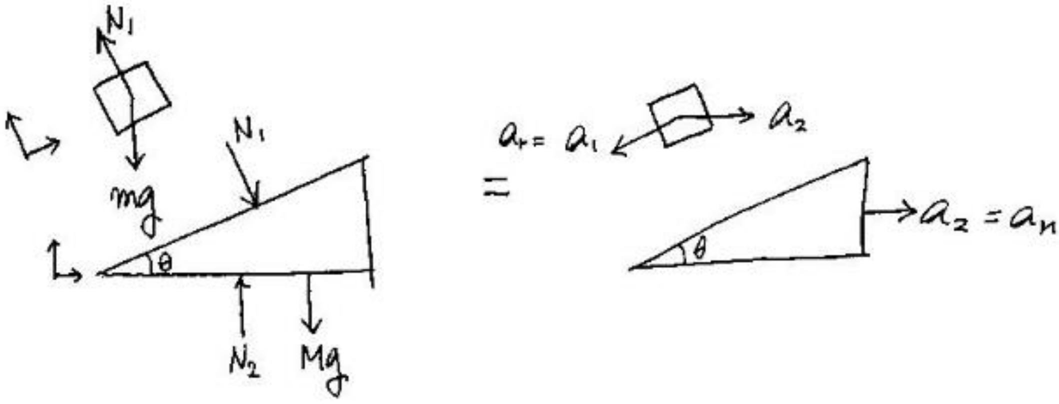
2)



$F = (m+M)a$

$\therefore\ a = \dfrac{F}{m+M}.$

Problem 15 (20 points)



For M : $N_2 - Mg - N_1\cos\theta = 0$

$$N_1 \sin\theta = M a_2$$

For m : $N_1 - mg\cos\theta = -m a_2 \sin\theta$

$$-mg\sin\theta = m(-a_1 + a_2\cos\theta)$$

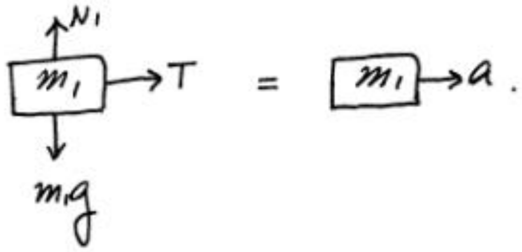
$$\therefore \quad a_M = \frac{mg\sin\theta\cos\theta}{M + m\sin^2\theta}, \quad a_r = \frac{mg\sin\theta\cos^2\theta}{M + m\sin^2\theta} + g\sin\theta.$$

$$N_1 = \frac{M}{\sin\theta} a_2 = \frac{Mmg\cos\theta}{M + m\sin^2\theta}$$

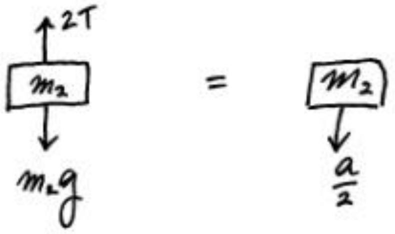
$$N_2 = Mg + N_1\cos\theta = Mg + \frac{Mmg\cos^2\theta}{M + m\sin^2\theta}.$$

Problem 16 (20 points)

Problem 16.



$T = m_1 a.$

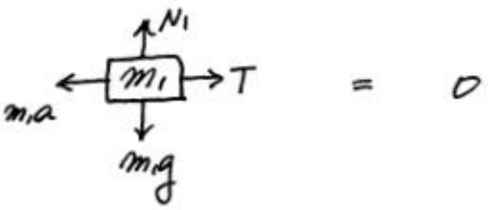


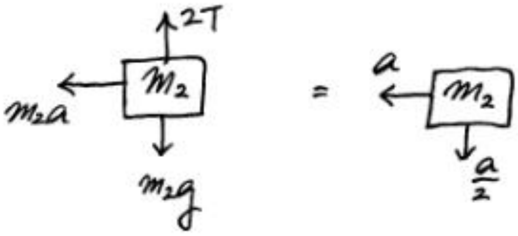
$m_2 g - 2T = m_2 \cdot \frac{a}{2}$

1) $a_1 = \dfrac{2m_2 g}{4m_1 + m_2}$, $a_2 = \dfrac{m_2 g}{4m_1 + m_2}$.

2) $T_1 = \dfrac{2m_1 m_2 g}{4m_1 + m_2}$, $T_2 = \dfrac{4m_1 m_2 g}{4m_1 + m_2}$.

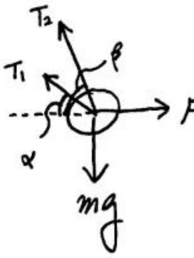
4)





Problem 17 (10 points)

Problem 17.



$$= 0$$

$$\Sigma F_x = 0; \quad F - T_1 \cos\alpha - T_2 \cos\beta = 0.$$

$$\Sigma F_y = 0; \quad T_1 \sin\alpha + T_2 \sin\beta - mg = 0.$$

The force in cable AC is zero

$$\Rightarrow \quad T_1 = 0$$

$$\Rightarrow \quad \begin{cases} F - T_2 \cos\beta = 0 \\ T_2 \sin\beta - mg = 0 \end{cases}$$

$$\Rightarrow \quad \tan\beta = \frac{mg}{F}$$

$$\Rightarrow \quad \frac{d + l_1}{l_2} = \frac{mg}{F}$$

$$\therefore \quad d = \frac{mg}{F} l_2 - l_1$$

Problem 18 (10 points)

1) Bicycle transition between public bicycle stations
2) Daejeon
3) Bicycle stations which have higher utilization, bicycle path that are often used by users, etc.
4) Which station has higher priority when more bicycles are allocated?