The University of Jordan
Physics Department

Chapter 4: Newton's Laws of Motion
Solutions to Suggested Probems | Giancoli 7th edition

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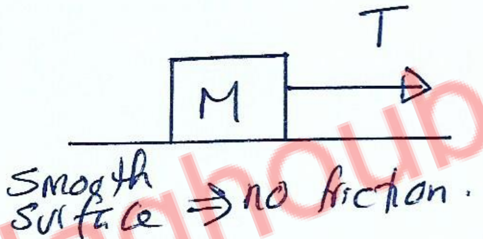
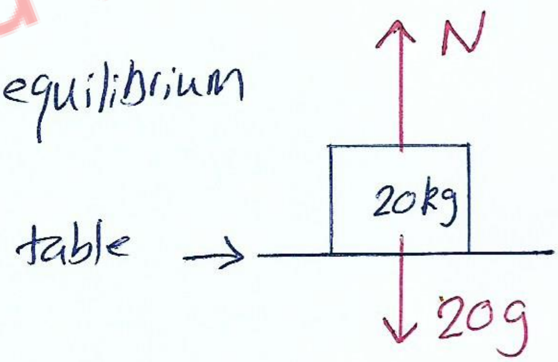
Q3] $T = ma$
$= 1210 \times 1.2$
$= 1452$ N.



Q11]
a) block rests on table ⇒ static equilibrium
⇒ $\sum \vec{F} = m\vec{a} = 0$.
$\overset{+}{\uparrow}$ $N - 20g = 0 \Rightarrow N = 20g$.



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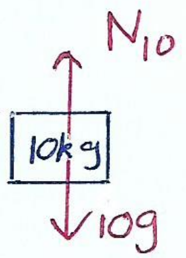
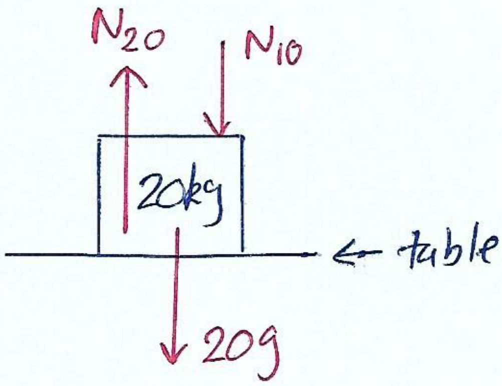
b) Draw free-body diagram for each block separately.
Both blocks are in static equilibrium.
for 10 kg: $\overset{+}{\uparrow}$ $N_{10} - 10g = 0 \Rightarrow N_{10} = 10g$.

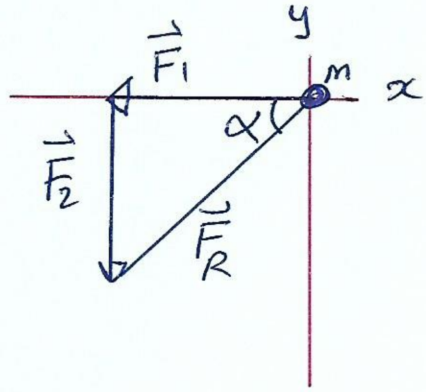
for 20 kg: $\overset{+}{\uparrow}$ $N_{20} - N_{10} - 20g = 0$
$N_{20} = 30g = 294$ Newtons.





Q28] Note we are looking at the system from the top. $F_1 = 10.2\,N$, $F_2 = 16\,N$, $m = 18.5\,kg$

a]



$\vec{F}_R = \vec{F}_1 + \vec{F}_2$

$F_R = \sqrt{F_1^2 + F_2^2} \approx 18.97\,N$

$F_R = ma \Rightarrow a = \frac{F_R}{m} \approx 1.03\, m/s^2$

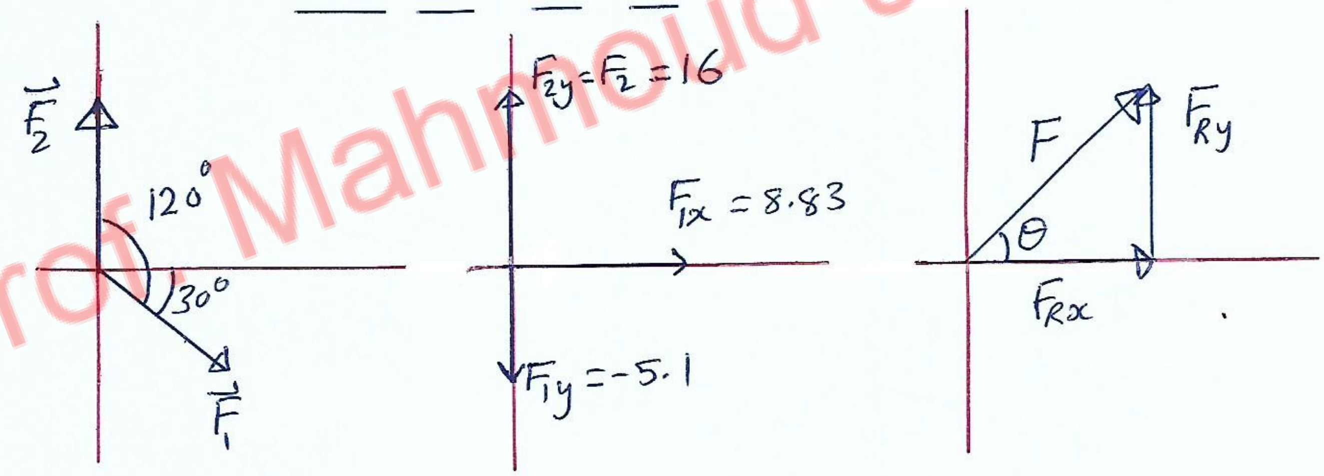
$\tan\alpha = \left|\frac{F_2}{F_1}\right| \Rightarrow \alpha \sim 57.48^\circ$

$\Rightarrow$ angle with positive x-axis in counterclockwise direction is $\theta = 180^\circ + \alpha = 237.48^\circ$.

$\vec{a}$ is in the direction of the resultant force $\vec{F}_R$.

since $\vec{a} = \frac{1}{m}\vec{F}_R$.

b]



Resolve forces into components.

$F_{1x} = F_1 \cos 30^\circ = 8.83\,N$, $F_{1y} = -F_1 \sin 30 = -5.1\,N$.

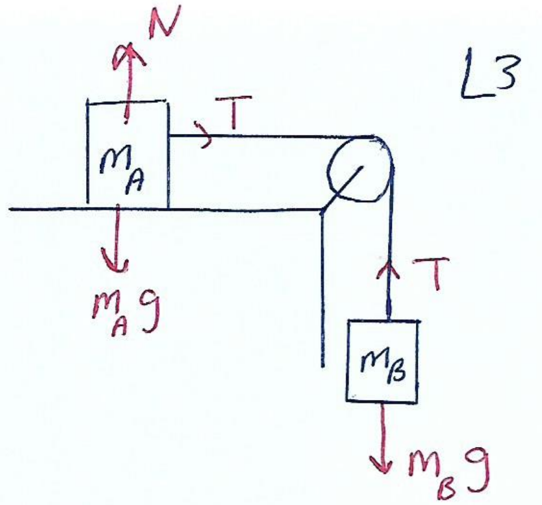
$\vec{F}_R = \vec{F}_1 + \vec{F}_2 \Rightarrow F_{Rx} = 8.83\,N$, $F_{Ry} = 16 - 5.1 = 10.9\,N$

$F_R = \sqrt{(5.1)^2 + (10.9)^2} \approx 14.03\,N \Rightarrow a = \frac{F_R}{m} \simeq 0.76\, m/s^2$

$\tan\theta = \left|\frac{F_{Ry}}{F_{Rx}}\right| \Rightarrow \theta \approx 51^\circ$

$\vec{a} \parallel \vec{F}_R$.

31] Smooth surfaces:



for m_B:

$\overset{\downarrow}{+}$ $m_B g - T = m_B a$ — ①

for m_A:

$\rightarrow +$ $T = m_A a$ — ②

① + ② $\Rightarrow$ $m_B g = (m_A + m_B) a$

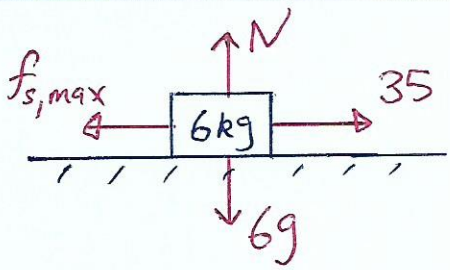
$$a = \left(\frac{m_B}{m_A + m_B}\right) g$$

Note that we ignore the masses of the pulley and string.

substitute for a in eq. (2) $\Rightarrow$

$$T = \left(\frac{m_A m_B}{m_A + m_B}\right) g \, .$$

36] a) To start the box moving the force of 35 must just exceed the maximum static friction $\Rightarrow$



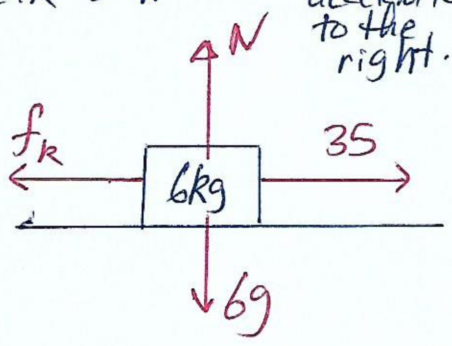
$\rightarrow +$ $35 - f_{s,max} = 0$, $a = 0$ as object will be on verge of moving but has NOT moved yet.

$\overset{+}{\uparrow}$ $N - 6g = 0 \Rightarrow N = 6g$.

therefore, $35 = \mu_s N = \mu_s (6g) \Rightarrow \mu_s = 35/6g \simeq 0.6$

b) As soon as the box moves, we have kinetic friction instead of static friction Note $f_k < f_{s,max} \Rightarrow f_k < 35$ and box accelerate to the right.

motion to the right $\Rightarrow$ we take right direction as positive.

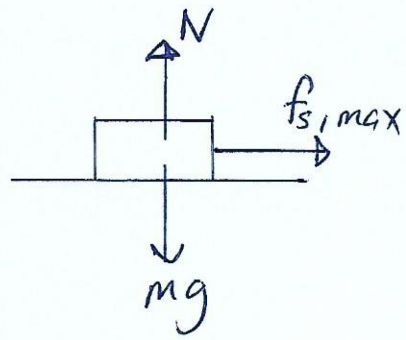


$\rightarrow +$ $35 - \mu_k N = 6(0.6)$

$$\Rightarrow \mu_k = \frac{35 - 3.6}{6g} \simeq 0.53$$

37] No motion along y-direction

$\Rightarrow \overset{+}{\uparrow} \; N - mg = 0 \Rightarrow N = mg.$



If you are not to slide and move with the train $\Rightarrow$ $f_{s,max}$ must be equal or greater than the force needed to give you an acceleration equals to that of the train which is ma (your mass x your acceleration)

$\therefore \; f_{s,max} \geq ma$

$\mu_s N \geq ma \Rightarrow \mu_s (mg) \geq ma \Rightarrow \mu_s \geq \frac{a}{g}$

$\therefore \; \mu_s \geq \frac{0.2g}{g} = 0.2 \Rightarrow \mu_s \geq 0.2$

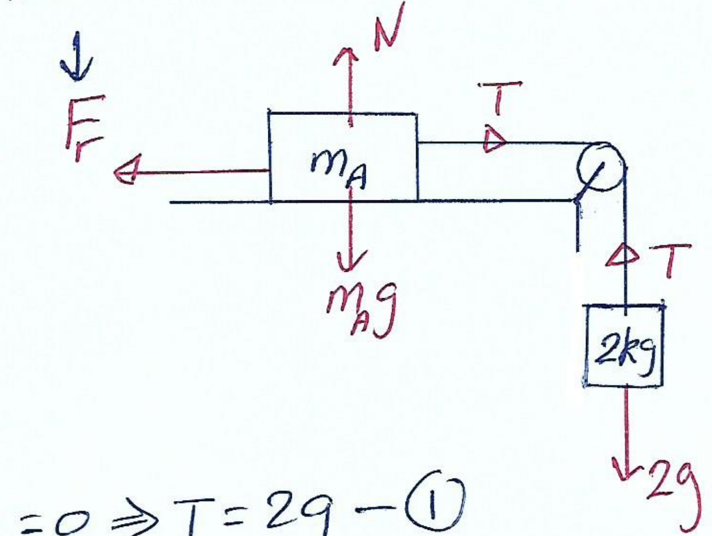
if $\mu_s < 0.2 \Rightarrow$ you will slide

if $\mu_s = 0.2 \Rightarrow$ you are on verge of sliding

if $\mu_s > 0.2$ you will have the same acc. as the train and will move will the train.

Note that the force of friction is the force that causes your motion with the train.

45] $\mu_s = 0.4$
$\mu_k = 0.2$



a) keep system from starting to move ⇒ system at rest in static equilibrium ⇒ $\Sigma \vec{F} = 0$

$\therefore a = 0$

for 2 kg mass $\downarrow +$ $-T + 2g = 0 \Rightarrow T = 2g$ — ①

Also m_A is not moving ⇒ $F_r \leq f_{s,max}$.

$\rightarrow +$ $T - F_r = 0 \Rightarrow T = F_r \leq f_{s,max}$

$\therefore T \leq f_{s,max}$ but using ① $T = 2g \Rightarrow$

$2g \leq \mu_s (N)$

$2g \leq \mu_s (m_A g) \Rightarrow m_A \geq \frac{2}{\mu_s} \Rightarrow m_A \geq 5$ kg.

If $m_A = 5$ kg ⇒ system will be on verge of motion.

If $m_A < 5$ kg ⇒ system will move ($m_A \rightarrow$, 2kg $\downarrow$)

If $m_A > 5$ kg system will not move.

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b) System oving at constant speed ⇒ $a = 0$ (dynamic equilibrium)
in this case $F_r = f_k$ ← kinetic friction.

for m_A $\rightarrow +$ $T - f_k = 0$ — ①

for 2kg. $\downarrow +$ $2g - T = 0$ — ②

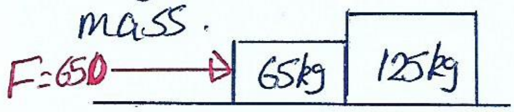
①+② ⇒ $2g - f_k = 0 \Rightarrow f_k = 2g$

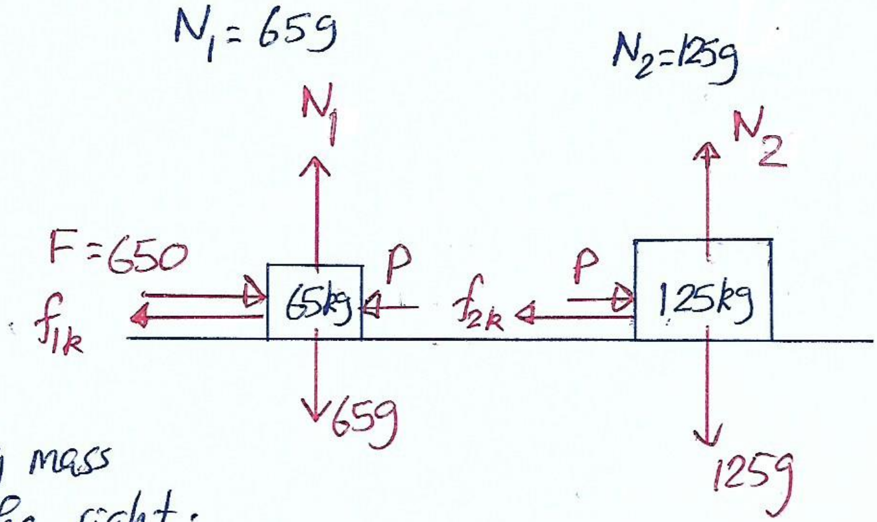
$\therefore \mu_k N = 2g \Rightarrow \mu_k (m_A g) = 2g$

$\therefore m_A = \frac{2}{\mu_k} = 10$ kg.

47] $\mu_k = 0.18$

a) Draw a free body diagram for each mass.





a) F acts on the 65 kg mass and system moves to the right.

for 65kg mass:

$\rightarrow + \quad 650 - f_{1k} - P = 65a \quad -①$

for 125kg

$\rightarrow + \quad P - f_{2k} = 125a \quad -②$

$①+② \Rightarrow 650 - f_{1k} - f_{2k} = (65+125)a$

$f_{1k} = \mu_k N_1 \quad , f_{2k} = \mu_k N_2$

$$\Rightarrow a = \frac{650 - 0.18 \times 65g - 0.18 \times 125g}{190} \simeq 1.66 \text{ m/s}^2$$

using ② $\quad P = 428$ Newtons.

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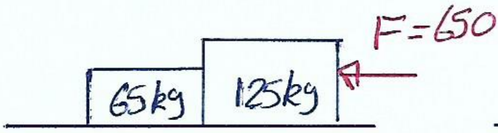
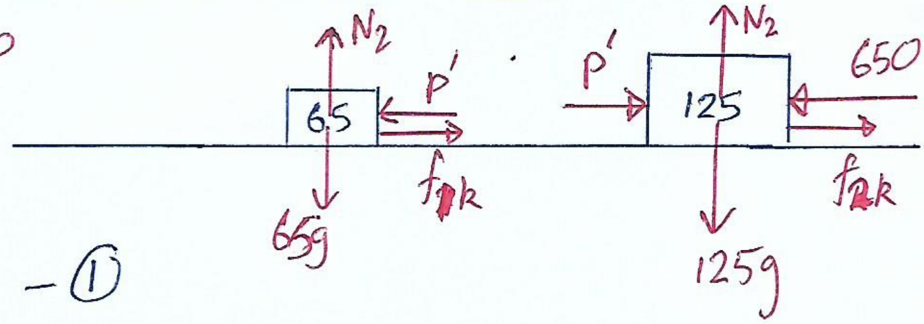
b)





motion to the left $\Rightarrow$

$+\leftarrow \quad 650 - f_{2k} - P' = 125a \quad -①$

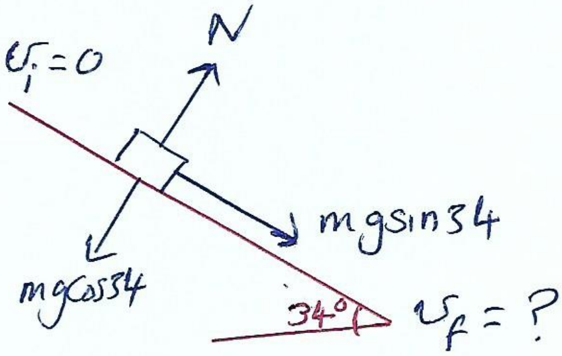
$+\leftarrow \quad P' - f_{1k} = 65a \quad -②$

$①+② \Rightarrow a = 1.66 \text{ m/s}^2$ as before.

from ② $\quad P' = f_{1k} + 65a \approx 222.56$

NOTE: $P' < P$ since P' accelerates the small 65 kg mass but P accelerates the larger 125 kg mass.

59] <u>First</u> calculate the final speed assuming surfaces are smooth i.e NO FRICTION.



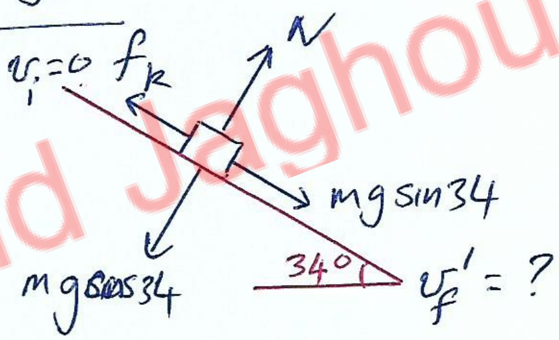
$\searrow +$ $mg\sin 34 = ma$

$\therefore a = g\sin 34$

$v_f^2 - v_i^2 = 2a\,\Delta x$ ← displacement down inclined plane

$v_f^2 = 2(g\sin 34)\Delta x \Rightarrow v_f = \sqrt{2g\sin 34\,\Delta x}$

Now assume there is friction.



$\searrow +$ $mg\sin 34 - f_k = ma$

$mg\sin 34 - \mu_k(mg\cos 34) = ma'$

$\therefore a' = g\sin 34 - \mu_k g\cos 34$

<u>Note</u> $N - mg\cos 34 = 0$

$\therefore v_f'^2 - v_i^2 = 2a'\,\Delta x$

$v_f'^2 = 2(g\sin 34 - \mu_k g\cos 34)\Delta x$

$\therefore v_f' = \sqrt{2g(\sin 34 - \mu_k\cos 34)\Delta x}$

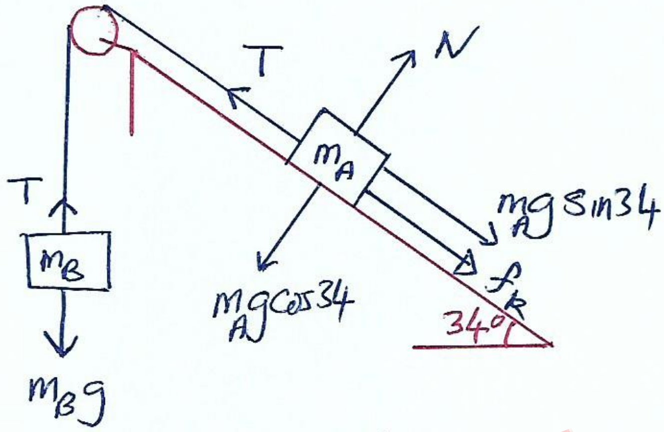
we are given $\frac{v_f}{v_f'} = 2 \Rightarrow 2 = \sqrt{\frac{2g\sin 34\,\Delta x}{2g(\sin 34 - \mu_k\cos 34)\Delta x}}$

$\Rightarrow \mu_k \approx 0.51$

<u>Note</u> you did not need the value of Δx

61] $m_A = m_B = 2.7$ kg , $\mu_k = 0.15$

a) m_B moves down and m_A moves up the inclined plane. This is given in question.



for m_B :

$\downarrow +$ $\quad m_B g - T = m_B a$ —(1)

$\nwarrow +$ $\quad T - m_A g \sin 34 - f_k = m_A a$ —(2)

(1) + (2) ⇒

$$m_B g - m_A g \sin 34 - f_k = (m_A + m_B)\, a$$

Note:
$N = m_A g \cos 34$

$$a = \frac{m_B g - m_A g \sin 34 - \mu_k (m g \cos 34)}{m_A + m_B} \quad \text{—(3)}$$

$a \simeq 1.6$ m/s^2.

b) System not accelerating ⇒ $a = 0$

from (3) ⇒ $m_B g - m_A g \sin 34 - \mu_k (m_A g \cos 34) = 0$

∴ $\mu_k \simeq 0.53$.