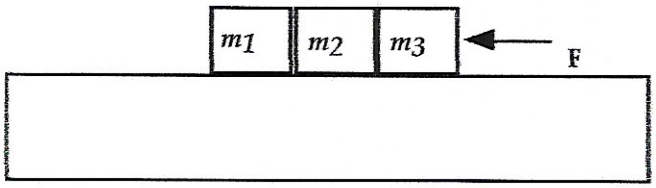
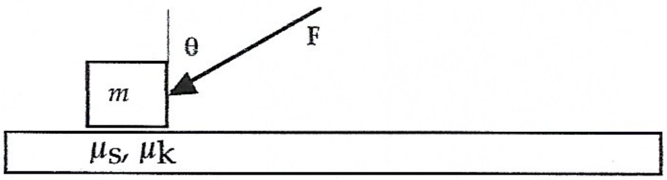
Ch 5



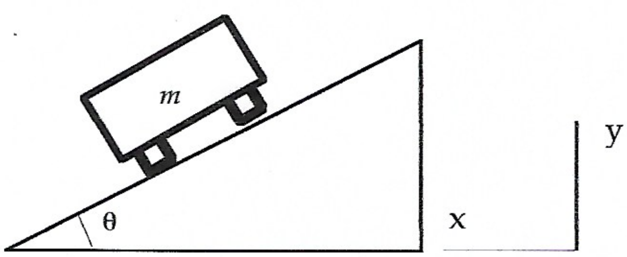
Question 1 The three masses move smoothly under the effect of an external force parallel to ground. The surface is frictionless and **F** is parallel to the ground. Give your answers in terms of the given quantities (**F** and masses).

A. Draw a free body diagram (FBD) for ***each*** mass and show **ALL** the forces acting on it.
B. Use your FBD to write down Newton's 2nd law for ***each*** mass.
C. Obtain the acceleration of each mass
D. Obtain the force acting on each mass by the other



Questions 2 The object is initially at rest then starts moving. **F** is at an angle θ with respect to the vertical.

A. Draw a FBD and show **ALL** the forces acting on the mass. Do not show any extreneous forces or components.
B. Use your FBD to write down Newton's 2nd law for the mass.
C. State how your answers will change precisely if the force flips its direction.
D. Obtain each force acting on the mass
E. Obtain its acceleration prior to motion, the moent it starts, during motion

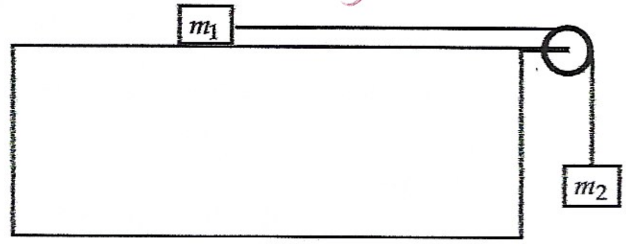


Question3 While going at a constant speed, a train makes a turn whose radius is r. The road is banked at an angle of θ. Let μ represents the either coefficient of friction.

A. Draw a FBD and show **ALL** the forces acting on the mass when μ=0. Do not show any extreneous forces or components.
B. Use your FBD to write down Newton's 2nd law for the mass.
C. Obtain all the forces acting on the train
D. Obtain the acceleration without friction.
E. State the condition for the friction to be (1) up hill, (2) down hill.
F. Obtain the acceleration of the train when friction is present.

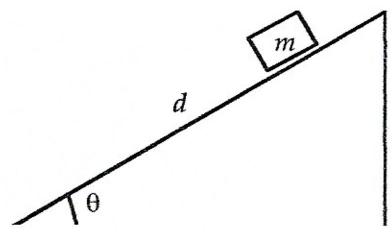
Question 4 A bucket of water tied to a rope is revolving in a vertical loop of radius r.

A. Draw a FBD and show **ALL** the forces acting on the mass when the bucket is (i) at the top (ii) at the bottom of the loop. Do not show any extreneous forces or components.
B. Use your FBD to write down Newton's 2nd law for the bucket.
C. When the bucket is at the top of the loop, what has to be its speed v_t for the rope to remain taut with zero tension?
D. If the speed of the bucket at the bottom is v_b, what is the normal force on the water by the bucket at the bottom of the loop?



Questions 5 In the system shown above, the block of mass m_1, is on a rough horizontal table. The string that attaches it to the block of mass m_2 passes over a frictionless pulley of negligible mass. Let μ represent either coefficient of friction.

A. Draw a FBD and show **ALL** the forces acting on each mass.
B. Use your FBD to write down Newton's 2nd law for each mass.
C. Obtain all the forces acting on each mass.
D. Obtain the acceleration of each mass.
E. Obtain the tension in the rope.



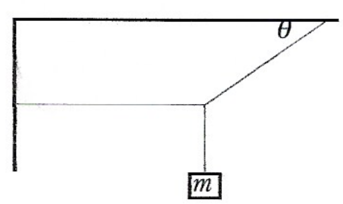
Question 6 A block of mass m is placed on a rough inclined table of angle θ at a distance d from the bottom. The coefficients of friction are μ_k and μ_s. The block starts from rest, then accelerates down hill.

A Draw a FBD and show **ALL** the forces acting on the mass.
B Use your FBD to write down Newton's 2nd law for the mass.
C Obtain all the forces acting on the mass and its acceleration
D In terms of the given quantities in the problem, (i) what will be its speed at the bottom of the hill and (ii) how long will it take to get there?

Question 7 A rock of mass m is inside an elevator. The floor of the elevator is actually a scale.

A Draw a FBD and show **ALL** the forces acting on the rock when the elevator is accelerating (i) up (ii) down.
B Use your FBD to write down Newton's 2nd law for the rock.
C Obtain the scale's reading when the elevator is

1. accelerating up with $a \uparrow$
2. accelerating down with $a \downarrow$
3. moving up at a constant velocity of $v \uparrow$
4. moving down at a constant velocity of $v \downarrow$
5. at rest



Questions 8
A mass m is suspended from a wall and a ceiling as shown in the figure.

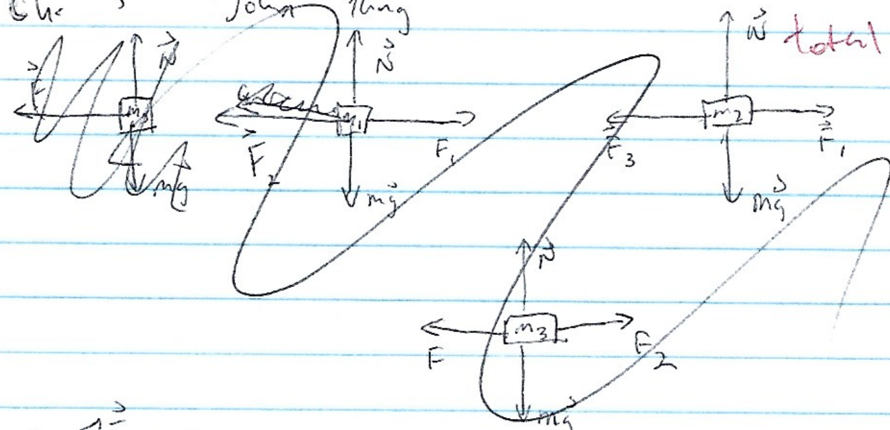
A. Draw a FBD and show **ALL** the forces acting on the mass.
B. Use your FBD to write down Newton's laws.
C. Obtain the tension in each rope in terms of m, θ, and g.
D. Order the three tensions from the largest to the smallest.

black 65
blue 9
red 14
88

total: ~~88~~ 90 expected

Ch 5 John Yang

1) a)



b) m_1: $\Sigma \vec{F}_1 = m_1 a$

$\Sigma \vec{F}_{y_1} = m_1 a_{y_1} = 0$ $\qquad \Sigma \vec{F}_{x_1} = m_1 a_{x_1}$

$\vec{N}_1 + m\vec{g} = 0$ $\qquad \vec{F}_2 + \vec{F}_1 = m_1 a_{x_1}$

$\vec{N}_1 = -m_1\vec{g}$

m_2: $\Sigma \vec{F}_2 = m_2 a$

$\Sigma F_{y_2} = m_2 a_{y_2} = 0$ $\qquad \Sigma F_{x_2} = m_2 a_{x_2}$

$\vec{N}_2 + m_2 g = 0$ $\qquad \vec{F}_3 + \vec{F}_1 = m_2 a_{x_2}$

$N_2 = -m_2 g$ $\qquad \vec{F}_1 = -\vec{F}_3 + m_2 a_{x_2}$

m_3: $\Sigma \vec{F}_3 = m_3 a$

$\Sigma F_{y_3} = m_3 a_{y_3} = 0$ $\qquad \Sigma \vec{F}_{x_3} = m_3 a_{x_3}$

$\vec{N} + m_3 g = 0$ $\qquad \vec{F} + \vec{F}_2 = m_3 a_{x_3}$

$\vec{N}_3 = -m_3\vec{g}$ $\qquad \vec{F}_2 = -\vec{F} + m_3 a_{x_3}$

c) m_1: $\vec{F}_2 + \vec{F}_1 = m_1 a_{x_1}$ $\qquad m_2$: $\vec{F}_3 + \vec{F}_1 = m_2 a_{x_2}$

$a_{x_1} = \dfrac{\vec{F}_2 + \vec{F}_1}{m_1}$ $\qquad a_{x_2} = \dfrac{\vec{F}_3 + \vec{F}_1}{m_2}$

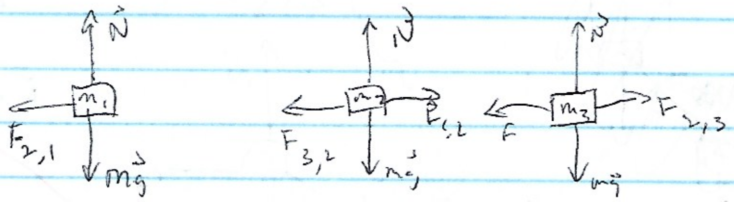
m_3: $\vec{F} + \vec{F}_2 = m_3 a_{x_3}$

$a_{x_3} = \dfrac{\vec{F} + \vec{F}_2}{m_3}$

d) $\vec{F}_1$: $\vec{F}_1 + \vec{F}_2 = m_1 a_{x_1}$ $\qquad \vec{F}_3 + \vec{F}_1 = m_2 a_{x_2}$ $\qquad \vec{F} + \vec{F}_2 = m_3 a_{x_3}$

Ch-5 John Yan

1) a)



+11

b) $\sum F_{1x} = m_1 a$ $\quad$ $\sum F_{1y} = m_1 a_y = 0$

$\underline{F_{2,1} = m_1 a_x}$ +1 $\quad$ $\vec{N}_1 + m_2\vec{g} = 0$

$\vec{N}_1 = -m_2\vec{g}$

$\sum F_{2x} = m_2 a$ $\quad$ $\sum F_{2y} = m_2 a_{2y} = 0$

$\underline{\vec{F}_{3,2} + \vec{F}_{1,2} = m_2 a_{2x}}$ +1 $\quad$ $\vec{N}_2 = -m_2\vec{g}$

$\sum F_{3x_3} = m_3 a$ $\quad$ $\sum F_{3y} = m_3 a_{3y} = 0$

$\underline{F + F_{2,3} = m_3 a}$ +1 $\quad$ $\vec{N}_3 = -m_3\vec{g}$

nice

c) $a = \frac{F_{2,1}}{m_1}$ $\quad$ $a = \frac{F_{3,2} + F_{1,2}}{m_2}$ $\quad$ $a = \frac{F + F_{2,3}}{m_3}$

$F_{3,2} = m_2 a - F_{1,2}$ $\quad$ $F_{3,2} = -F_{2,3}$

$F_{2,1} = m_1 a$ $\quad$ $F_{1,2} = -F_{2,1}$

$-m_1 a = F_{1,2}$

$F_{3,2} = m_2 a + m_1 a \rightarrow F_{2,3} = -m_2 a - m_1 a$

$a = \frac{F - m_2 a - m_1 a}{m_3}$

$m_3 a + m_2 a + m_1 a = F$

$a(m_1 + m_2 + m_3) = F$ +1

$\boxed{a = \frac{F}{m_1 + m_2 + m_3}}$ +1

d)

$F_{3,2} = m_2 a + m_1 a$

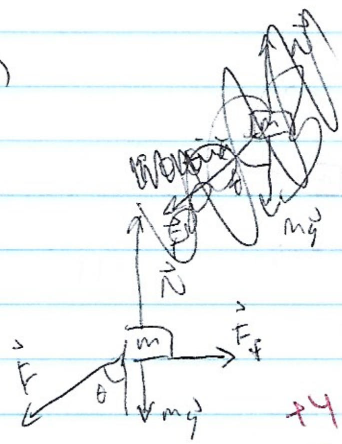
$= \cancel{\frac{Fm_2}{m_1+m_2+m_3} + \frac{Fm_1}{m_1+m_2+m_3}}$

$\boxed{F_{3,2} = \frac{F(m_1 + m_2)}{m_1 + m_2 + m_3}}$ $\quad$ $F_{2,1} = m_1 a = \boxed{\frac{Fm_1}{m_1 + m_2 + m_3}}$

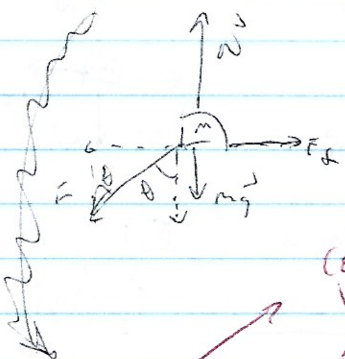
Simplify

16

2) a)



b) $\sum F_x = m a_x$ $\quad \sum F_y = m a_y = 0$



$\vec N + m\vec g + \vec F \cos\theta = 0$

Combine into 1 eqn. as vectors

~

+4

b) $\vec F \sin\theta + \vec F_f = m a_x = ma$

c) $m\vec g$ will be greater than the normal force & F_f will be less. ~

d) $\vec N = m\vec g$ +1 ; $N = -m\vec g - \vec F\cos\theta$ +1

$F_f = \mu_k N = \boxed{-\mu_k m\vec g - \mu_k \vec F\cos\theta}$ +1

$\vec F\sin\theta = ma - \vec F_f$

$\sin\theta F = ma + \mu_k m\vec g + \mu_k F\cos\theta$

$F(\sin\theta - \mu\cos\theta) = m(a + \mu_k g)$

$F = \boxed{\dfrac{ma - \mu_k mg}{\sin\theta - \mu_k\cos\theta}}$

e) prior to motion - $a = 0$ since $F_f \le \mu_s N$

start of motion - $F_f = \mu_s N$

$a = \dfrac{\vec F\sin\theta + \vec F_f}{m} = \dfrac{\vec F\sin\theta - \mu_s \vec N}{m}$

$= \dfrac{F\sin\theta - \mu_s m\vec g - F\cos\theta}{m}$

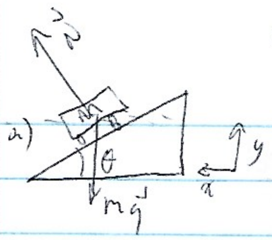
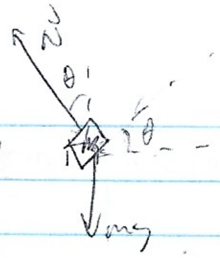
$a = \boxed{\dfrac{F}{m}(\sin\theta - \cos\theta) - \mu_s \vec g}$ ~

during motion - $a = \dfrac{F\sin\theta - F_f}{m} = \dfrac{F\sin\theta - \mu_k m\vec g - \mu_k F\cos\theta}{m}$

$a = \boxed{\dfrac{F}{m}(\sin\theta - \mu_k\cos\theta) - \mu_k\vec g}$

+1

8

3) a)  

b) $\Sigma F_y = ma_y = 0$

$N\cos\theta + m\vec{g} = 0$

$N\cos\theta = -m\vec{g}$

b) $\Sigma F_x = ma_x = \frac{mv^2}{r}$

$N\sin\theta = \frac{mv^2}{r}$

combine

~

c) $\boxed{W = m\vec{g}}$ +1

$$\boxed{N = \frac{mv^2\sin\theta}{r} = \frac{-m\vec{g}}{\cos\theta}}$$

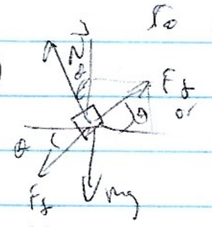
~ ~

d) $a = \frac{\Sigma F_x}{m} = \frac{N\sin\theta}{m} = \frac{-mg\sin\theta}{m\cos\theta} = \boxed{-g\tan\theta}$ +1

e) (i) if friction is acting uphill, ~~the ... bank in the ...~~ $N\sin\theta$ is too large, which means the ~~...~~ bank is too steep

(ii) if friction is down hill, the curve isn't steep enough so friction needs to provide additional centripetal force.

~ speed

f) 

(a) +3

$\Sigma F_y = ma = 0$

$N\cos\theta + F_f\sin\theta + m\vec{g} = 0$

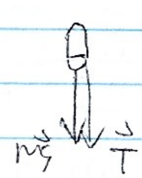
$\Sigma F_x = ma$: $N\sin\theta \pm F_f\cos\theta = ma$

$a = \frac{\Sigma F_x}{m} = \frac{N\sin\theta \pm F_f\cos\theta}{m}$ ~

$= -g\tan\theta \pm \frac{\frac{\mu m\vec{g}}{\cos\theta}(\cos\theta)}{m}$ ~

$= \boxed{-g\tan\theta \pm \mu\vec{g}}$ ~

4) a) (ii) 

(i) 

+4

9

b) $\sum F_y = ma_z$

$\vec{T} \pm m\vec{g} = ma$ +1

~

c) $T + mg = ma = \frac{mv_t^2}{r}$

$T = 0$ $\quad \cancel{m}g = \frac{\cancel{m}v_t^2}{r}$ +1

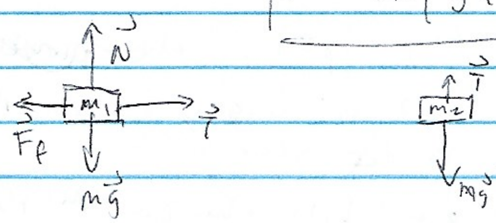
$v_t^2 = rg$ $\quad \boxed{v_t = \sqrt{rg}}$ +1

d) $\sum F_b = ma$

$\vec{N} - mg = ma = \frac{mv_b^2}{r}$

$\boxed{\vec{N} = m\left(g + \frac{v_b^2}{r}\right)\uparrow}$ +1

5) a)



+6

b) $\sum F_{1y} = ma_y = 0$

$\vec{N} + m\vec{g} = 0$

$N = -m\vec{g}$

$\sum F_{1x} = m_1 a_1$

$\vec{T}_1 + \vec{F}_f = m_1 a_1$ ~

~

$\sum F_{2y} = m_2 a_2$

$m_2\vec{g} - \vec{T}_2 = m_2 a_2$ ~

c) $F_f = \mu N = \boxed{-\mu m\vec{g}}$ +1

~

$F_{g2} = \boxed{m_2 g}$ +1

$T_1 = m_1 a_1 - F_f = m_1 a_1 + \mu m g$

$T_2 = m_2 g - m_2 a_2$

d) $a_1 = a_2 = a$ $\quad T_1 = T_2 = T$

$m_2 g - m_2 a = m_1 a + \mu m_1 g$

$a(m_1 + m_2) = m_2 g - \mu m_1 g$

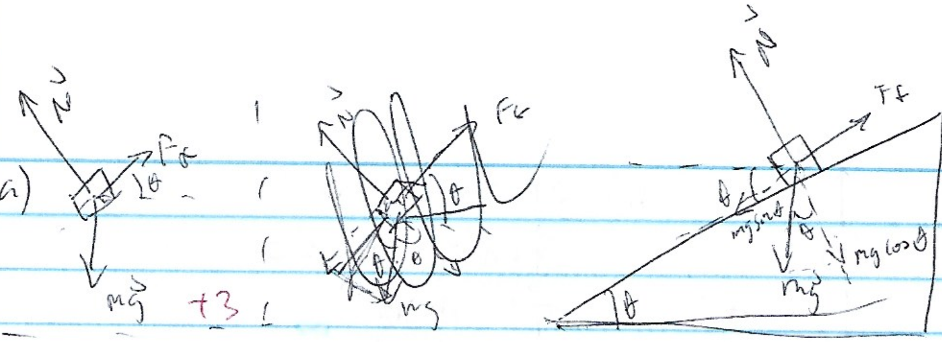
$a = \boxed{\frac{m_2 g - \mu m_1 g}{m_1 + m_2}}$ +1

e) $T = m_2 g - m_2 a = m_2 g - \frac{m_2(m_2 g - \mu m_1 g)}{(m_1 + m_2)}$

$= \frac{m_1 m_2 g + \cancel{m_2^2 g} - \cancel{m_2^2 g} + \mu m_1 m_2 g}{m_1 + m_2} = \boxed{\frac{m_1 m_2 g(\mu + 1)}{m_1 + m_2}}$ +1

14

6) a)



+3

b) $\sum F_{\parallel} = ma$ $\qquad$ $\sum F_{\perp} = ma = 0$

$mg\sin\theta\swarrow + F_f\nearrow = ma$ $\qquad$ $\vec{N}_{\nwarrow} + mg\cos\theta\searrow = 0$

+1

c) $w = mg\downarrow$; +1 $\vec{N} = mg\cos\theta\nwarrow$; +1

$F_f = ma - mg\sin\theta = \mu_k N = \boxed{\mu_k mg\cos\theta\nearrow}$ +1

$a = \dfrac{\sum F_{\parallel}}{m} = \dfrac{mg\sin\theta\swarrow + \mu_k mg\cos\theta\nearrow}{m}$

~

$= \boxed{g\sin\theta - \mu_k g\cos\theta} = \boxed{g(\sin\theta - \mu_k\cos\theta)}$ +1

d) $v_f^2 = \cancel{v_0^2} + 2ad$

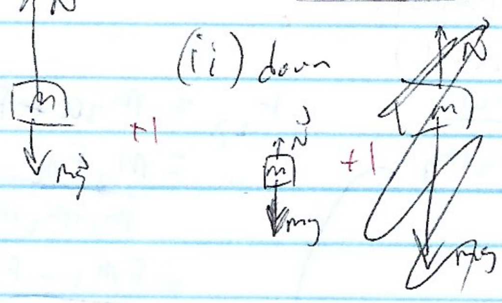
(i) $v_f = \sqrt{2ad} = \cancel{\sqrt{2d(g\sin\theta - \mu_k g\cos\theta)}}$

$= \boxed{\sqrt{2gd(\sin\theta - \mu_k\cos\theta)}}$ +1

(ii) $v_f = \cancel{v_0} + at$

$t = \dfrac{v_f}{a} = \boxed{\dfrac{\sqrt{2gd(\sin\theta - \mu_k\cos\theta)}}{g(\sin\theta - \mu_k\cos\theta)}}$ ~

7) a)(i) up $\qquad$ (ii) down



+1 $\qquad$ +1

b) $\sum F = ma$ $\qquad$ c) $N = mg\downarrow + ma$ $\qquad$ 1) $N = mg\downarrow + ma\uparrow$

$\vec{N} - m\vec{g} = ma$ $\qquad\qquad$ $= \boxed{mg\downarrow - ma\downarrow}$ switch

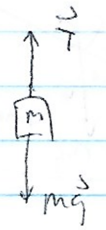
~ vector $\qquad\qquad$ 2) $N = \boxed{mg\uparrow + ma\uparrow}$ ~

~~3) a=0~~ $\quad$ 3, 4) $a = 0$; $\vec{N} - m\vec{g} = ma = 0$

+1 $\qquad$ $N = \boxed{m\vec{g}}$ +1 $\qquad$ 5) $a = 0$; $N = \boxed{m\vec{g}}$ +1

14

8) a)



+2

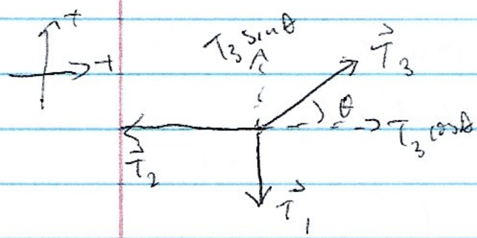
b) $\sum F = ma = 0$

$\vec{T}\uparrow + m\vec{g}\downarrow = ma = 0$

$\vec{T}\uparrow = -mg$

$|T| = |mg|$

+1



c)

$\vec{T}_1 + \vec{T}_2 + \vec{T}_3 = 0$

$\boxed{T_1 = -mg}$ ~

$-mg + \vec{T}_2 + \vec{T}_3 = 0$

$T_3 \cos\theta = -T_2 \rightarrow T_2 = -T_3\cos\theta$

$= \frac{-mg\cos\theta}{\sin\theta}$

$T_3 \sin\theta = -T_1$

$T_3 \sin\theta = +mg$

$\boxed{T_3 = \frac{mg}{\sin\theta}}$ +1 $\boxed{T_2 = \frac{-mg}{\tan\theta}}$ ~

d) $|T_1| = mg$

$|T_2| = \frac{mg}{\tan\theta}$ $|T_3| = \frac{mg}{\sin\theta}$ $\theta < 90°$

let $\theta = 30°$ $\sin\theta = 0.5$ $\tan\theta = 0.6$

$\frac{mg}{\sin\theta} = 2mg$ $\frac{mg}{\tan\theta} = mg(0.6^{-1}) = 1.7mg$

Smallest T_1 (vertical)
T_2 (horizontal)
Largest T_3 (diagonal)

~ 4

1) d) $F_{3,2} = \frac{F(m_1+m_2)}{m_1+m_2+m_3}$

$F_{2,3} = m_3 a - F$

$= \frac{m_3 F}{m_1+m_2+m_3} - F$

$= \frac{F m_3 - F(m_1+m_2+m_3)}{m_1+m_2+m_3}$

$= \frac{-F(m_1+m_2)}{m_1+m_2+m_3}$

$\boxed{F_{3,2} = -F_{2,3}}$

+1 1

$F_{2,1} = \frac{F m_1}{m_1+m_2+m_3}$

$F_{1,2} = m_2 a - F_{3,2}$

$= \frac{F(m_1+m_2)}{m_1+m_2+m_3} + m_2 a$

$= \frac{F m_2 - F(m_1+m_2)}{m_1+m_2+m_3}$

$= \frac{-F m_1}{m_1+m_2+m_3}$

$\boxed{F_{2,1} = -F_{1,2}}$ +1

2) b) $\Sigma \vec{F} = m\vec{a}$

$\boxed{\vec{N} + m\vec{g} + \vec{F}_f + \vec{F} = m\vec{a}}$ +1

c) proof - $\Sigma F_x = m a_x = ma$

$F_f = \mu_s N$ $\quad F \sin\theta - F_f = ma$

$a = \frac{F}{m}\sin\theta - \frac{F_f}{m}$

$= \frac{F}{m}\sin\theta - \frac{\mu_s \cancel{m} g}{\cancel{m}} - \frac{\mu_s F\cos\theta}{m}$

$\boxed{= \frac{F}{m}(\sin\theta - \mu_s\cos\theta) - \mu_s g}$ +1

3) b) $\Sigma \vec{F} = m\vec{a}$

$\vec{N} + \vec{F}_f + m\vec{g} = m\vec{a}$ +1

c) (signage) $|N| = \frac{mg}{\cos\theta}$ ~

e) (i) ~~[illegible]~~

$\Sigma F = ma = \frac{mv^2}{r}$

$= N\sin\theta \pm F_f\cos\theta = \frac{mv^2}{r}$

~~[illegible]~~ ~~$F_f\cos\theta = N\sin\theta \pm \frac{mv^2}{r}$~~

~

if $F_f \leftarrow$ (+), going too slowly

if $F_f \rightarrow$ (-), going too fast (trucks going too fast on curves will tip over b/c not enough friction)

4

3) a) $\sum F = ma$

$N\sin\theta \pm F_f = ma$ $\qquad$ $N\cos\theta = mg \uparrow$

$a = \frac{N\sin\theta}{m} \pm \frac{F_f}{m}$ $\qquad$ $N = \frac{mg}{\cos\theta}$

$= \frac{mg}{\cos\theta}\left(\frac{\sin\theta}{m}\right) \pm \frac{\mu N}{m}$

$= g\tan\theta \pm \frac{\mu mg}{m\cos\theta}$ ~

$a \boxed{= g\tan\theta \pm \frac{\mu g}{\cos\theta}}$ ~

4) b) $\sum F_y = ma$ $\qquad$ bottom $\qquad$ top

$\vec{T} + m\vec{g} = m\vec{a}$ $\qquad$ $\vec{T} + m\vec{g} = ma$

$T - mg = ma\uparrow$ $\qquad$ $T + mg = ma\downarrow$ +1

5) b) $\sum F_1 = m_1 a$ $\qquad$ $\sum F_2 = m_2 a$

$\vec{N} + m\vec{g} + \vec{F}_f + \vec{T} = m_1 a$ $\qquad$ $\vec{T} + m\vec{g} = m_2 a$ ✓

c) $\boxed{N_1 = m_1 g}$ +1 $\boxed{N_1 = -m_1 g}$ +1

a) $\qquad$ 7) c) 1) $a\uparrow$ $\qquad$ $\vec{N}\uparrow + m\vec{g}\downarrow = m\vec{a}\uparrow$

$N\uparrow = m\vec{a}\uparrow + mg\uparrow$ +1

$= m(a+g)$

b) $\sum F = ma$

$\boxed{\vec{N} + m\vec{g} = m\vec{a}}$ $\qquad$ 2) $a\downarrow$ $\qquad$ $N\uparrow + mg\downarrow = ma\downarrow$

+1

$N\downarrow = ma\uparrow - mg\uparrow$

$N\uparrow = mg\uparrow - ma\uparrow$ +1

$= m(g-a)$

6

8) c) $\sum \vec{F} = m\vec{a} = 0$

$\vec{T}\uparrow + m\vec{g}\downarrow = m\vec{a} = 0$

$\boxed{T\uparrow = mg\uparrow}$ +1

$T_2 = T_3 \cos\theta = \boxed{\dfrac{mg\cos\theta}{\sin\theta}}$ +1

2

3) c) $N\cos\theta \pm \mu N\sin\theta = mg$ +1

$N = \dfrac{mg}{\cos\theta \pm \mu\sin\theta}$ +1 $\quad F_f \leq \dfrac{\mu mg}{\cos\theta \pm \mu\sin\theta}$ +1

e) if friction uphill, too slow +1
if friction downhill, too fast

f) $N\sin\theta \mp F_f\cos\theta = ma$

$\dfrac{mg\sin\theta}{\cos\theta \pm \mu\sin\theta} \mp \dfrac{\mu mg\cos\theta}{\cos\theta \pm \mu\sin\theta} = ma$ +1

$a = g\,\dfrac{\sin\theta \mp \mu\cos\theta}{\cos\theta \pm \mu\sin\theta}$ +1

5) b) $T - \mu mg = m_1 a$ +1

6) d) $d = \bar{v}t = \dfrac{v_f t}{2}$; $v_f = \int a\,dt = g(\sin\theta - \mu\cos\theta)t = g(\sin\theta - \mu\cos\theta)\dfrac{2d}{v_f}$

$v_f = \sqrt{2dg(\sin\theta - \mu\cos\theta)}$

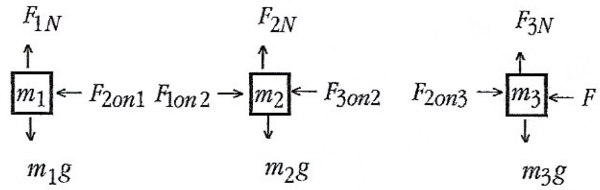
$a = g(\sin\theta - \mu\cos\theta) \quad v = gt(\sin\theta - \mu\cos\theta)$

$d = \int v\,dt = \frac{1}{2}gt^2(\sin\theta - \mu\cos\theta)$

$t = \sqrt{\dfrac{2d}{\sin\theta - \mu\cos\theta}}$ +5

8) d) $F_3 > F_1, F_2$; F_1, F_2 : depends on θ -2

Question 1



A. *1 pt for each correctly drawn and labeled force vector. [11 pts]*

B. All masses have the same acceleration since they move together. In addition, for each mass, $\vec{F_N}+m\vec{g}=0$; therefore, we have

$\vec{F}_{2on1}=m_1\vec{a}$ 1 pt

$\vec{F}_{1on2}+\vec{F}_{3on2}=m_2\vec{a}$ 1 pt

$\vec{F}_{2on3}+\vec{F}=m_3\vec{a}$ 1 pt

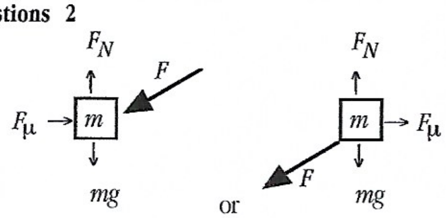
$\vec{F}=(m_1+m_2+m_3)\vec{a}$ 1 pt

C. They all have the same acceleration $\vec{a}=\dfrac{\vec{F}}{m_1+m_2+m_3}$ 1 pt

D. $\vec{F}_{2on1}=m_1\vec{a}=\dfrac{m_1\vec{F}}{m_1+m_2+m_3}=-\vec{F}_{1on2}$ 1 pt

$\vec{F}_{3on2}=m_2\vec{a}-\vec{F}_{1on2}=\dfrac{(m_1+m_2)\vec{F}}{m_1+m_2+m_3}=-\vec{F}_{2on3}$ 1 pt

Questions 2



A. *1 pt for each correctly drawn and labeled force vector [4 points]*
Take off 1 pt for any component or extreneous force vector.

B. $\vec{F}+\vec{F}_\mu+\vec{F}_N+m\vec{g}=m\vec{a}$ 1 pt

or $F\sin\theta-F_f=ma$, $F_N-F\cos\theta-mg=0$, $F_f\leq\mu F_N$

C. $\vec{F}+\vec{F}_\mu+\vec{F}_N+m\vec{g}=m\vec{a}$ 1 pt

or $F\sin\theta-F_f=ma$, $F_N+F\cos\theta-mg=0$, $F_f\leq\mu F_N$ 20

D. $\vec{F}_g=mg\downarrow$ 1 pt

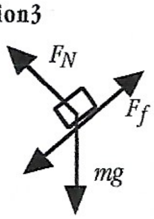
$\vec{F}_N=(mg+F\cos\theta)\uparrow$ 1 pt

$\vec{F}_f\leq\mu(mg+F\cos\theta)\rightarrow$ *against the motion.* 1 pt

E. (i) $a=\dfrac{F}{m}\sin\theta-\mu_s(g+\dfrac{F}{m}\cos\theta)$ 1 pt

(ii) & (iii) $a=\dfrac{F}{m}\sin\theta-\mu_k(g+\dfrac{F}{m}\cos\theta)$ 1 pt

Question3



A.

What you need to keep in mind in this problem is that the acceleration is toward the center and parallel to the ground NOT the surface of the incline!

1 pt for each correctly drawn and labeled force vector. Either direction (uphil or downhill) for frition is acceptable but you must specify that it is against the direction of motion. [3 pts]
Take off 1 pt for any component or extreneous force vector.

B. $\vec{F}_\mu+\vec{F}_N+m\vec{g}=m\vec{a}$ 1 pt

or $F_N\sin\theta\pm F_f\cos\theta=ma$, $a=\dfrac{v^2}{r}$

$F_N\cos\theta\pm F_f\sin\theta-mg=0$, $F_f\leq\mu F_N$

C. Fromthe second equation above

$F_N\cos\theta\pm\mu F_N\sin\theta=mg$ 1 pt

$F_N=\dfrac{mg}{\cos\theta\pm\mu\sin\theta}$ 1 pt, $F_f\leq\dfrac{\mu mg}{\cos\theta\pm\mu\sin\theta}$ 1 pt 30

D. If $\mu=0$, the x-direction 2nd law equation gives

$F_N\sin\theta\pm F_f\cos\theta=ma$, $F_N\sin\theta\pm0=ma$ 1 pt

$a=g\dfrac{\sin\theta}{\cos\theta}=g\tan\theta$ 1 pt

E. If the speed is low, i.e. $a<gr\tan\theta$ & $v<\sqrt{gr\tan\theta}$, the friction will be up hill; otherwise, $a>gr\tan\theta$ & $v>\sqrt{gr\tan\theta}$ and down hill. 1 pt

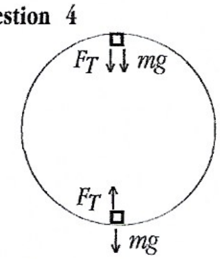
F. $F_N\sin\theta\mp F_f\cos\theta=ma$

$\dfrac{mg\sin\theta}{\cos\theta\pm\mu\sin\theta}\mp\dfrac{\mu mg\cos\theta}{\cos\theta\pm\mu\sin\theta}=ma$ 1 pt

$a=g\dfrac{\sin\theta\mp\mu\cos\theta}{\cos\theta\pm\mu\sin\theta}$ 1 pt

37

Question 4



A.

1 pt for each correctly drawn and labeled force vector
Take off 1 pt for any component or extreneous force vector. [4 pts]

B. (Top) $\vec{F}_T+m\vec{g}=m\vec{a}$, $F_T+mg=ma$ 1 pt ma

(Bottom) $\vec{F}_T+m\vec{g}=m\vec{a}$, $F_T-mg=ma$ 1 pt

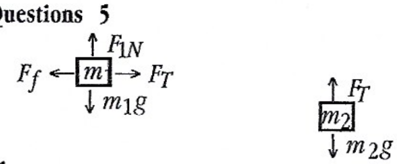
C. If the tension is zero at the top, and the backet completes the loop while still saing on the loop, we have to have

$0+mg=ma=m\dfrac{v^2}{r}$ 1 pt, $v=\sqrt{gr}$ 1 pt

D. $F_T-mg=ma$ 1 pt, $F_N=F_T=m(a+g)=m\left(g+\dfrac{v^2}{r}\right)$ 1 pt

47

Questions 5



A.

1 pt for each correctly drawn and labeled force vector
Take off 1 pt for any component or extreneous force vector. [6 pts]

B. $\vec{F}_T+\vec{F}_f+\vec{F}_N+m_1\vec{g}=m_1\vec{a}$, $F_T-\mu m_1g=m_1a$ 1 pt 60

$\vec{F}_T+m_2\vec{g}=m_2\vec{a}$, $m_2g-F_T=m_2a$ 1 pt

C. $\vec{F}_{1g}=m_1g\downarrow$ *1 pt*, $\vec{F}_N=m_1g\uparrow$ *1 pt*, $\vec{F}_f=\mu m_1g\leftarrow$ *1 pt*,

$\vec{F}_{2g}=m_2g\downarrow$ *1 pt*

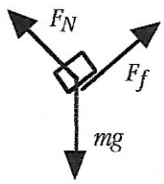
D. Solving $F_T-\mu m_1g=m_1a$ and $m_2g-F_T=m_2a$ simultaneously gives $(m_2-\mu m_1)g=(m_1+m_2)a$ 1 pt 60

and $a=\dfrac{m_2-\mu m_1}{m_1+m_2}g$ 1 pt

E. $F_T - \mu m_1 g = m_1 a$ or $m_2 g - F_T = m_2 a$ gives

$$F_T = (1+\mu)\frac{m_1 m_2}{m_1 + m_2} g$$ *1 pt*

Question 6



A. *The acceleration is along the incline.*
1 pt for each correctly drawn and labeled force vector. Either direction (uphil or downhill) for frition is acceptable but you must specify that it is against the direction of motion. [3 pts]
Take off 1 pt for any component or extreneous force vector. 100

B $\vec{F}_\mu + \vec{F}_N + m\vec{g} = m\vec{a}$ or *1pt*

$mg\sin\theta - \mu mg\cos\theta = ma$ and $F_N - mg\cos\theta = 0$

C $F_g = mg$ *1 pt*, $F_N = mg\cos\theta$ *1 pt*, $F_f \le \mu mg\cos\theta$ *1 pt*

D We can solve the problem two different ways, find v_f first or t first. Since initial velocity is 0 and a is constant, we have

$d = v_{av}t = \frac{v_f}{2}t$ *1 pt* and 70

$$v_f = \int a\,dt = g(\sin\theta - \mu\cos\theta)t = g(\sin\theta - \mu\cos\theta)\frac{2d}{v_f}$$ *1 pt*

$$v_f = \sqrt{2dg(\sin\theta - \mu\cos\theta)}$$ *1pt*

$a = g(\sin\theta - \mu\cos\theta)$

$v = g(\sin\theta - \mu\cos\theta)t$

$$d = \int v\,dt = \frac{1}{2}g(\sin\theta - \mu\cos\theta)t^2$$ *1 pt*

$$t = \sqrt{\frac{2d}{\sin\theta - \mu\cos\theta}}$$ *1 pt*

Question 7

A (i) $\uparrow F_N$, $\square$, $\downarrow mg$ $= \uparrow ma$ *1pt* 60

(ii) $\uparrow F_N$, $\square$, $\downarrow mg$ $= \downarrow ma$ *1pt*

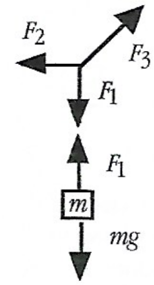
B In both cases, $\vec{F}_N + m\vec{g} = m\vec{a}$. Remember, this is the vector notation! **Not** the scalar form! *1pt*

C

1. $F_N \uparrow + mg \downarrow = ma \uparrow$, $F_N \uparrow = ma \uparrow - mg \downarrow = m(g+a) \uparrow$ *1pt*
   This is so because F_N has to account for both g and a.
2. $F_N \uparrow + mg \downarrow = ma \downarrow$, $F_N \uparrow = ma \downarrow - mg \downarrow = m(g-a) \uparrow$ *1pt*
3. $\vec{a} = 0$, $F_N \uparrow = mg \uparrow$ *1pt* 80
4. $\vec{a} = 0$, $F_N \uparrow = mg \uparrow$ *1pt*
5. $\vec{a} = 0$, $F_N \uparrow = mg \uparrow$ *1pt*

In other words, if you want to loose weight, weight yourself in an elevator accelerating down, better yet on free fall.

Questions 8



A. Since the question asks forces acting on the mass, you need to show only the two forces acting on it.
1 pt for each correctly drawn and labeled force vector acting on the mass. Take off 1 pt for any component or extreneous force vector acting on the mass. [2p ts]

B. $\vec{F}_1 + m\vec{g} = 0$, $\vec{F}_1 + \vec{F}_2 + \vec{F}_3 = 0$ *1pt* 80

C. $F_1 = mg$ *1pt*

$F_1 - F_3\sin\theta = 0$, $F_3 = \dfrac{mg}{\sin\theta}$ *1pt*

$F_2 - F_3\cos\theta = 0$, $F_2 = \dfrac{mg\cos\theta}{\sin\theta}$ *1pt*

D. F_3 is larger than both F_1 and F_2 *[1 pt]*, but the relative sizes of F_1 and F_2 depend on the angle θ since smaller the θ, the larger F_2 *[1 pt]*

85 90