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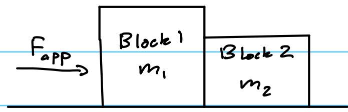
PHYS121 - HW2

Problem 1)

a)

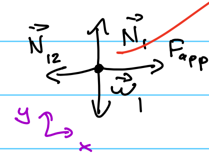


Frictionless

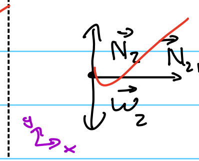
Given: $m_1 = 14.29\,kg$
$m_2 = 3.67\,kg$
$F_{app} = 16.84\,N$
$g = 9.81\,m/s^2$

Acceleration: Acceleration is positive, both blocks move in positive x direction

FBD 1



FBD2



b) Given/Assumption: $a_{1x} = a_{2x} = a_x$

Block 1 N2L

$F_x = m_1 a_x$

$F_{app} - N_{12} = m_1 a_x$

$F_{app} = m_1 a_x + N_{12}$ stop!

Block 2 N2L

$F_x = m_2 a_{2x}$

$N_{21} = m_2 a_x$ stop!

Too many unknowns!

$N_{21} = N_{12} = m_2 a_x$ by N3L

$\therefore F_{app} = m_1 a_x + m_2 a_x$

$F_{app} = (m_1 + m_2) a_x$

$\therefore \boxed{a_x = \frac{F_{app}}{(m_1 + m_2)}}$

Note about units: $\frac{N}{kg} = \frac{kg \cdot m/s^2}{kg} = m/s^2$

Numerically, $F_{app} = 16.84N$, $m_1 = 14.29\,kg$, $m_2 = 3.67\,kg$ $\therefore a_x = \frac{16.84\,N}{14.29\,kg + 3.67\,kg} = \boxed{0.938\,m/s^2}$

c) From part (b): $N_{21} = m_2 a_x$.

N3L tells us $N_{21} = N_{12}$ $\therefore N_{12} = m_2 a_x$

$a_x = \frac{F_{app}}{m_1 + m_2}$, $\boxed{N_{12} = m_2\left(\frac{F_{app}}{m_1 + m_2}\right)}$

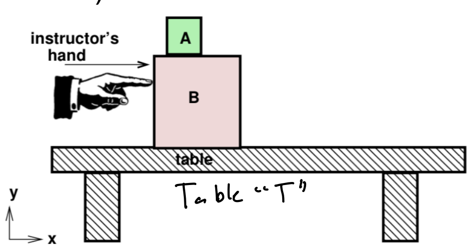
Numerically, $a_x = \frac{F_{app}}{m_1 + m_2} = 0.938\,m/s^2$

$m_2 = 3.67\,kg$

$N_{12} = 3.67\,kg(.938\,m/s^2) = \boxed{3.44\,N}$

Problem 2)

a)



Block A mass $= m_A$

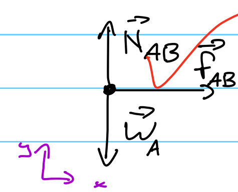
Block B mass $= m_B$

Table is frictionless!

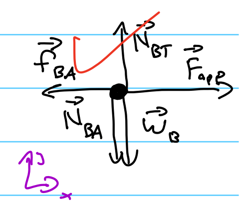
no slip, no slide

F_{app} on Block B

FBD A



FBD B



Acceleration in positive x-direction, no vertical acceleration!

b) $a_{Ax} = a_{Bx} = a_x$ as blocks "stuck" together, and $a_{Ay} = a_{By} = a_y = 0$

N2L $F_{Ay} = m_A a_{Ay}$, $a_{Ay} = 0$

$N_{AB} - W_A = 0$

$N_{AB} = W_A$, $W_A = m_A g$

$\boxed{W_A = N_{AB} = m_A g}$

Vertical Forces (in y-dir) for blocks A and B

N2L $F_{By} = m_B a_{By}$, $a_B = 0$

$N_{BT} - N_{BA} - W_B = 0$

$N_{BT} = N_{BA} + W_B$ $\boxed{W_B = m_B g}$

$\hookrightarrow N_{AB} = \boxed{N_{BA} = m_A g}$ by N3L

$\therefore \boxed{N_{BT} = (m_A + m_B) g}$

N2L $F_{Ax} = m_A a_{Ax}$

$f_{AB} = m_A a_x$ stop!

Too many unknowns! $\rightarrow$ $F_{app} = m_B a_x + f_{BA}$ Stop!

N2L $F_{Bx} = m_B a_{Bx}$

$F_{app} - f_{BA} = m_B a_x$

N3L $f_{AB} = f_{BA} = m_A a_x$ F_{app} is known!

$\therefore F_{app} = m_B a_x + m_A a_x \Rightarrow F_{app} = a_x(m_A + m_B)$

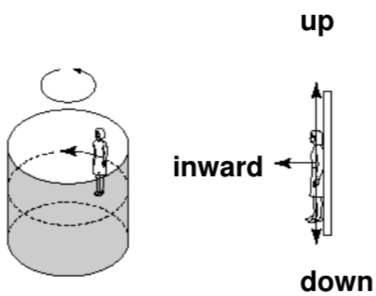
using a_x calculated to the right... $\therefore \boxed{a_A = a_B = a_x = \frac{F_{app}}{m_A + m_B}}$

$f_{AB} = m_A\left(\frac{F_{app}}{m_A + m_B}\right)$

N3L states $\boxed{f_{AB} = f_{BA} = \frac{m_A \cdot F_{app}}{m_A + m_B}}$

Problem 3)

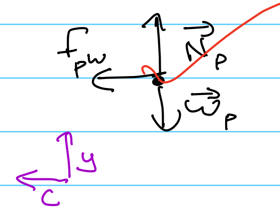
c)



Vertical Acceleration is 0, only centripital Accel.

UCM

FBD Person



friction on rider due to wall

b) Constant speed: V

Mass of rider: M

Barrel radius: R

useless → Coef. static friction: μ

$a_y = 0$, rider not falling

N2L $F_{p_y} = m_{p_y} a_y$

$N_p - W_p = 0$

$N_p = W_p$, $W_p = Mg$

$\boxed{N_p = W_p = M \cdot g}$

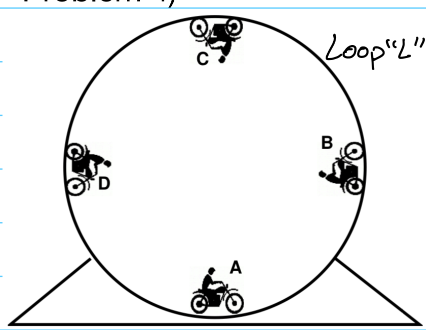
$a_c = \frac{V^2}{R}$, UCM

N2L $F_{p_c} = m_p a_c$

$f_{pw} = M \cdot \frac{V^2}{R}$

$\boxed{f_{pw} = \frac{M \cdot V^2}{R}}$

Problem 4)



Loop "L"

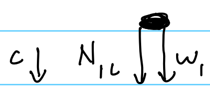
Rider + Motorcycle is one point with mass m

Radius of path = R

Rider moving @ constant speed, V

* The track is not frictionless!

a) FBD Position C, denoted body 1



UCM, $a_c = \frac{V^2}{R}$

$\boxed{W_1 = mg}$

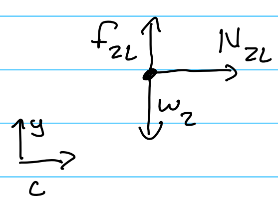
N2L $F_c = m a_c$

$W_1 + N_{1L} = m\left(\frac{V^2}{R}\right)$

$mg + N_{1L} = m\left(\frac{V^2}{R}\right)$

$\boxed{N_{1L} = m\left(\frac{V^2}{R} - g\right)}$

b) FBD Position D, denoted body 2



UCM, $a_c = \frac{V^2}{R}$

N2L $F_c = m a_c$

$\boxed{N_{2L} = m\left(\frac{V^2}{R}\right)}$

Friction present as tangential velocity = 0

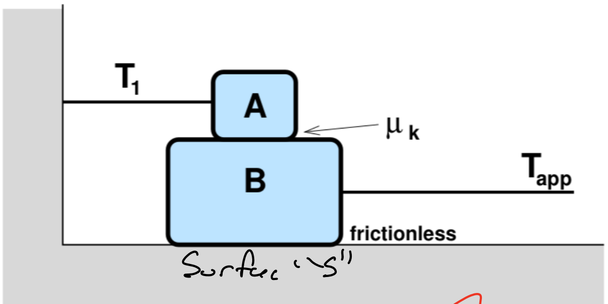
N2L $F_y = m a_y$, $a_y = 0$

$f_{2L} - W_2 = 0$

$f_{2L} = W_2$

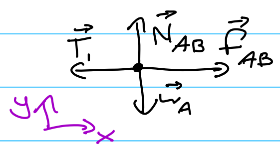
$\boxed{W_2 = mg}$ and $\boxed{f_{2L} = mg}$

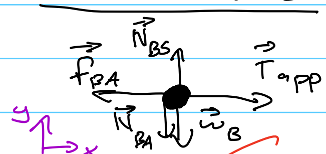
Problem 5)



- Block A mass = m_A
- Block B mass = m_B
- Friction btwn A and B, coef. of sliding friction = μ_k
- Block B sits on a frictionless surface
- Block B pulled by string with force T_{app}

a) FBD Block A   FBD Block B





b) The first pair is $\vec{f}_{AB}$ and $\vec{f}_{BA}$. We know these two are pairs because Block A is not moving to the right. Friction is attempting to pull the block with B when tension is applied, but T_1 prevents this. As a result, there must be an opposing force to hold A in place with respect to B, and that is $\vec{f}_{BA}$. Similarly, $\vec{N}_{AB}$ and $\vec{N}_{BA}$ must be paired together due to the fact that there is no vertical acceleration.

c) T_1 prevents Block A from moving, so a_{Ax} must be 0.

N2L $F_{Ax} = m_A a_{Ax},\ a_{Ax} = 0$

$f_{AB} - T_1 = 0$

$T_1 = f_{AB}$

given coef of static friction μ_k

$f_{AK} = \mu_K N_{AK}$

$f_{AB} = \mu_K (m_A \cdot g)$

$\therefore \boxed{T_1 = \mu_K (m_A \cdot g)}$

N2L $F_{Ay} = m_A a_y,\ a_y = 0$

$N_{AB} - w_A = 0$

$N_{AB} = w_A = m_A g$

d) N2L $F_{Bx} = m_B a_{Bx}$

$T_{app} - f_{BA} = m_B a_{Bx}$

$f_{AB} = f_{BA} = \mu_K (m_A g)$

$T_{app} - \mu_K (m_A g) = m_B a_{Bx}$

$$\boxed{a_{Bx} = \frac{T_{app} - \mu_K (m_A g)}{m_B}}$$