PHYS 2170

General Physics 3 for Majors

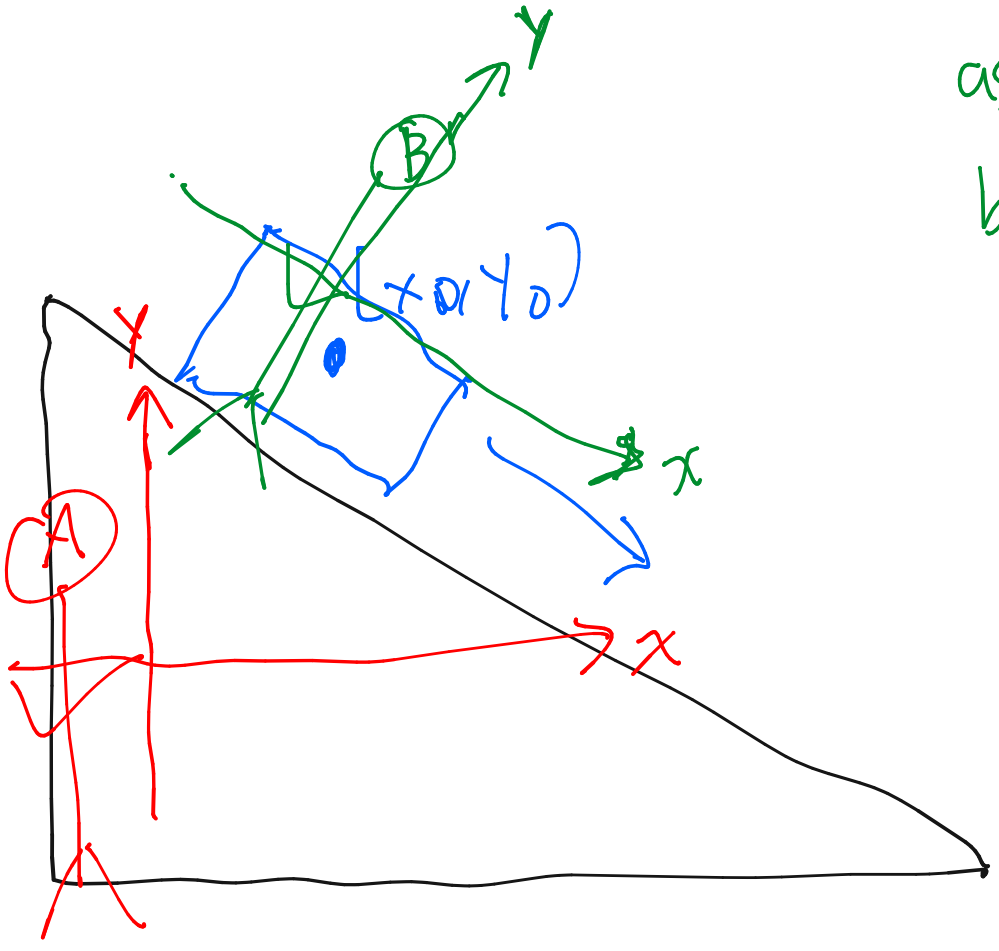
Fall 2021

Lecture 1

Galilean relativity

August 23

1 Physics is the same in multiple coordinate systems.



as seen by A: $x_A(t) = x_0 + \frac{1}{2}a_x t^2$

$y_A(t) = y_0 + \frac{1}{2}a_y t^2$

as seen by B: $x_B(t) = \frac{1}{2}at^2$

$y_B(t) = 0$

coordinates are relative

- same laws of physics $\vec{F} = m\vec{a}$
- what is $x(t)$? depends on A or B.

2 The laws of physics are the same in all inertial reference frames.

$\vec{F} = m\vec{a}$

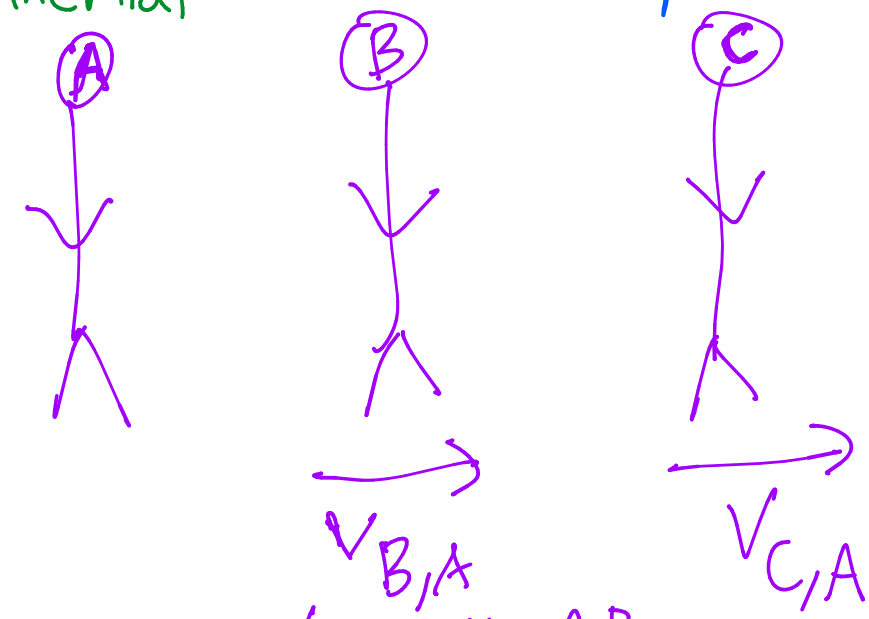
conservation of momentum

↓

Moving at constant velocity

observer / coordinate system

inertial



What is velocity of C, measured by B?

const. const.

$v_{C,B} = v_{C,A} - v_{B,A}$

(relative velocity)

$v_{C,B}$ = constant, so

if A sees B & C as inertial

B sees C is inertial

3 Two observers in different reference frames agree on the law of momentum conservation.

$[p = mv]$

if momentum conserved: $p_{1,A} + p_{2,A} = p'_{1,A} + p'_{2,A}$

$p_A = m_1 v_{1,A} + m_2 v_{2,A}$

$p_B = p_A - (m_1 + m_2)u$

$m_1 v_{1,A} + m_2 v_{2,A} = m_1 v'_{1,A} + m_2 v'_{2,A}$

$m_1 v_{1,B} + m_2 v_{2,B} = m_1 v'_{1,B} + m_2 v'_{2,B}$

$m_1[v_{1,A} - u] + m_2[v_{2,A} - u] = m_1[v'_{1,A} - u] + m_2[v'_{2,B} - u]$

A & B both agree mom. = conserved. disagree on momentum (p)

4 Two observers in different reference frames agree that $F = ma$.

observer A:

$\vec{F}_1 = m_1 a_{1,A}$ ⟷ equiv. ⟷ observer B:

$= m_1 \frac{dv_{1,A}}{dt}$

$F_1 \stackrel{?}{=} m_1 a_{1,B}$

force on particle 1

$a_{1,B} = \frac{d}{dt} v_{1,B}(t)$

$= \frac{d}{dt}\left[v_{1,A}(t) - u\right]$ (u: const.)

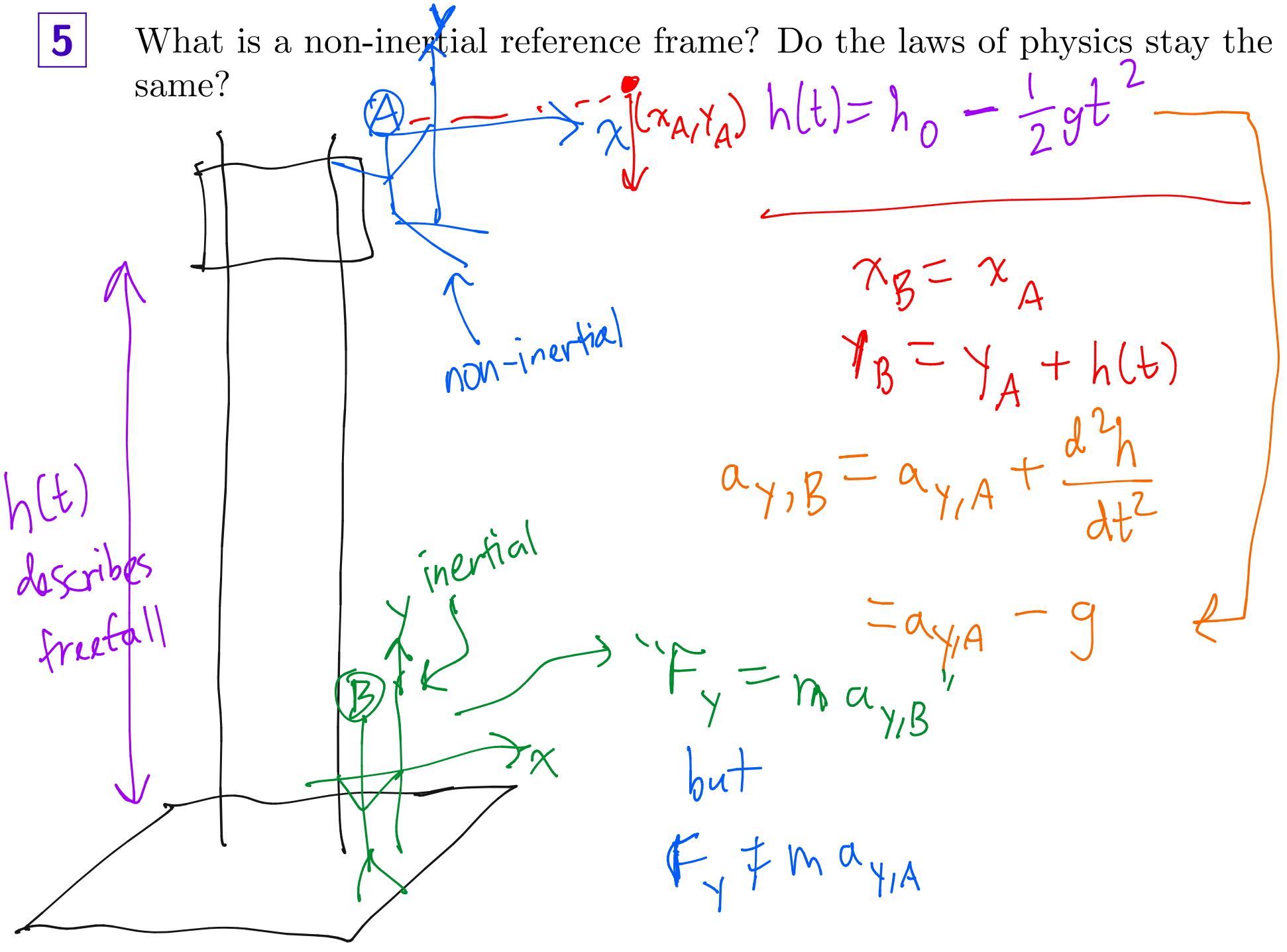
$= a_{1,A} - 0$

$= a_{1,A}$

empirical: m & F

frame-independents (invariant)

5 What is a non-inertial reference frame? Do the laws of physics stay the same?



(x_A, y_A) $h(t) = h_0 - \frac{1}{2}gt^2$

$x_B = x_A$

$y_B = y_A + h(t)$

$a_{y,B} = a_{y,A} + \frac{d^2h}{dt^2}$

$= a_{y,A} - g$

"$F_y = m a_{y,B}$"

but

$F_y \neq m a_{y,A}$