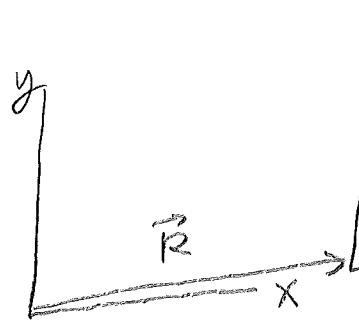
N9: Non inertial frames

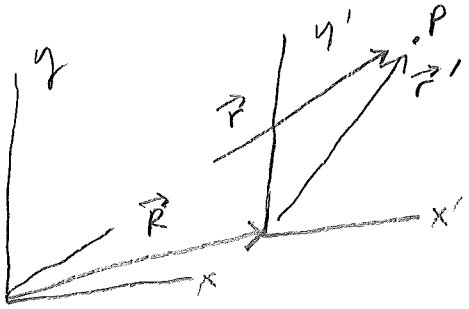
Skupin 2010



$\vec{R}$ = position of origin of S' w.r.t S

$\vec{\beta}$ = relative velocity of S' w.r.t. S

$= \frac{d\vec{R}}{dt}$



$\vec{r}$ = position of P w.r.t S

$\vec{r}'$ = " " " " S'

$$\vec{r} = \vec{r}' + \vec{R}$$

$$\begin{cases} \frac{d\vec{r}}{dt} = \frac{d\vec{r}'}{dt} + \frac{d\vec{R}}{dt} \\ \vec{v} = \vec{v}' + \vec{\beta} \end{cases}$$

[N9T.2]

$$\begin{cases} \frac{d\vec{v}}{dt} = \frac{d\vec{v}'}{dt} + \frac{d\vec{\beta}}{dt} \\ \vec{a} = \vec{a}' + \vec{A} \end{cases}$$

$\vec{A}$ = accel of S' rel. to S.

[N9B.8]

25 mph
11 m/s
11/0.12 = 93 m/s²
⇒ 9 gees

Let S be an inertial ref. frame (⇒ Newton's laws hold.) $\vec{F} = m\vec{a}$

If S' moves w/ const vel wrt. S, $\vec{\beta} = \text{const} \Rightarrow \vec{A} = 0$ then $\vec{a}' = \vec{a}$

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

⇒ S' is also an IRF [N9T.7]

If S' is accel wrt S, it is a non-inertial ref. frame &
fictitious forces appear:

$\vec{F} = m\vec{a} = m\vec{a}' + m\vec{A}$

or $\vec{F} + (-m\vec{A}) = m\vec{a}'$ [N9B.8]

$-m\vec{A} = \vec{F}_{fict.}$

If S' is accel wrt S, it is a <u>non inertial</u> ref frame

$\Rightarrow$ fictitious forces appear to operate in S'

S is inertial

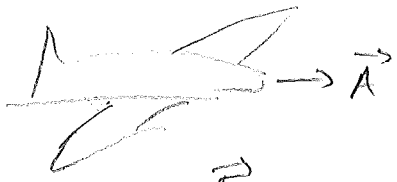
$$\vec{F} = m\vec{a} = m\vec{a}' + m\vec{A}$$

Since $\vec{F} \neq m\vec{a}'$, S' is non inertial

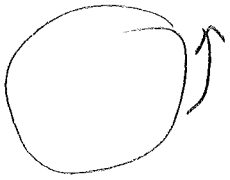
$$\vec{F} + (-m\vec{A}) = m\vec{a}'$$

$$\vec{F}_{fict}$$

eg accel. in plane



$$\vec{F}_{fict} = -m\vec{A}$$



rotating $\Rightarrow$ $\vec{A} = \frac{v^2}{r}\hat{r}$

$$\vec{F}_{fict} = -m\vec{A} = +\frac{mv^2}{r}\hat{r}$$

centrifug...

N9T.1 In a Western movie, a person shoots an arrow backward from a fleeing horse. If the velocity of the horse relative to the ground is 13 m/s west and the arrow's velocity relative to the horse is 38 m/s east, what is the arrow's velocity with respect to the ground?

A. 41 m/s east
B. 41 m/s west
C. 25 m/s east
D. 25 m/s west

N9T.2 A blimp has a velocity of 8.2 m/s due west relative to the air. There is a wind blowing at 3.5 m/s due north. The speed of the balloon relative to the ground is

A. 11.7 m/s
B. 8.9 m/s
C. 7.4 m/s
D. 4.7 m/s
E. Some other speed (specify)

N9T.3 An elevator moves downward with an acceleration of 6.2 m/s^2. A ball dropped from rest by a passenger will have what *downward* acceleration relative to the elevator?

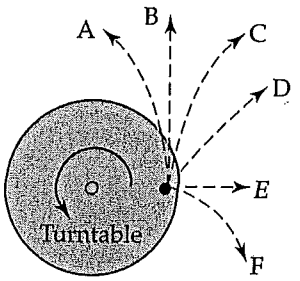
A. 3.6 m/s^2
B. 6.2 m/s^2
C. 9.8 m/s^2
D. 16.0 m/s^2
E. Some other acceleration (specify)

N9T.4 When you go over the crest of a hill in a roller coaster, a force appears to lift you up out of your seat. This is a fictitious force, true (T) or false (F)?

N9T.5 If your car is hit from behind, you are suddenly pressed back into the seat. The normal force that the seat exerts on you is a fictitious force, T or F?

N9T.6 You are pressed downward toward the floor as an elevator begins to move upward. The force pressing you down is a fictitious force, T or F?

N9T.7 A beetle (black dot on the top view shown at the right) sits on a rapidly rotating turntable. The table rotates faster and faster, and eventually the beetle loses its grip. What is its subsequent trajectory relative to the ground (assuming it cannot fly)?



N9T.8 When is an elevator a reasonably good inertial reference frame?

A. Never, under any circumstances.
B. Always, since it is attached to the surface of the earth.
C. It is except when it is changing speed.
D. Other conditions (describe).

N9T.9 Is a freely falling elevator an accurate inertial reference frame?

A. No, such a frame is accelerating toward the earth.
B. It is not a *real* inertial frame, but we can treat it as one if we ignore the gravitational forces on objects inside.
C. Yes.
D. It depends (explain).

N9B.8 A car originally moving at 25 mi/h hits a brick wall and comes to rest in 0.12 s. As the car comes to rest, about how fast will an unbelted passenger accelerate
(a) relative to the ground and
(b) relative to the windshield? Explain your response. (Ignore friction.)