

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Physics

Physics 8.01 TEAL

Fall Term 2004

Exam 1: Equation Summary

One Dimensional Kinematics:

$$\vec{v} = d\vec{r} / dt, \quad \vec{a} = d\vec{v} / dt \quad v_x(t) - v_{x,0} = \int_{t'=0}^{t'=t} a_x(t') dt' \quad x(t) - x_0 = \int_{t'=0}^{t'=t} v_x(t') dt'$$

Constant Acceleration:

$$x(t) = x_0 + v_{x,0}(t-t_0) + \frac{1}{2}a_x(t-t_0)^2 \quad v_x(t) = v_{x,0} + a_x(t-t_0)$$
$$y(t) = y_0 + v_{y,0}(t-t_0) + \frac{1}{2}a_y(t-t_0)^2 \quad v_y(t) = v_{y,0} + a_y(t-t_0)$$

where $x_0, v_{x,0}, y_0, v_{y,0}$ are the initial position and velocities components at $t = t_0$

Law of Addition of Velocities : $\vec{v}_{object, frame 1} = \vec{v}_{object, frame 2} + \vec{V}_{relative}$

Newton's Second Law: Force, Mass, Acceleration

$$\vec{F} \equiv m\vec{a} \quad \vec{F}^{total} = \vec{F}_1 + \vec{F}_2 \quad F_x^{total} = ma_x \quad F_y^{total} = ma_y \quad F_z^{total} = ma_z$$

Newton's Third Law: $\vec{F}_{1,2} = -\vec{F}_{2,1}$

Force Laws:

Universal Law of Gravity: $\vec{F}_{1,2} = -G \frac{m_1 m_2}{r_{1,2}^2} \hat{r}_{1,2}$, attractive

Gravity near surface of earth: $\vec{F}_{grav} = m_{grav} \vec{g}$, towards earth

Contact force: $\vec{F}_{contact} = \vec{N} + \vec{f}$, depends on applied forces

Static Friction: $0 \leq f_s \leq f_{s,max} = \mu_s N$ direction depends on applied forces

Kinetic Friction: $f_k = \mu_k N$ opposes motion

Hooke's Law: $F = k|\Delta x|$, restoring

Problem 1: (10 points) Concept Questions: Briefly answer the following questions.

a) **(5 points)** Two people are running forward at the same speed. One person throws a ball sideways to the other person at a constant speed v as seen by the thrower. Describe the motion of the ball as seen by a person standing on the ground. In particular according to the person on the ground is the ball moving faster, slower, or the same speed compared to the speed of the ball v as seen by the thrower?

Explain your answer:

~~b) **(5 points)** You are standing on a spring bathroom scale in an elevator and look at the scale while the elevator is at rest with respect to the ground. In between floors, when the elevator is moving at a constant speed with respect to the ground, you look at the scale again. Does the scale show a greater value, the same value, or a lower value?~~

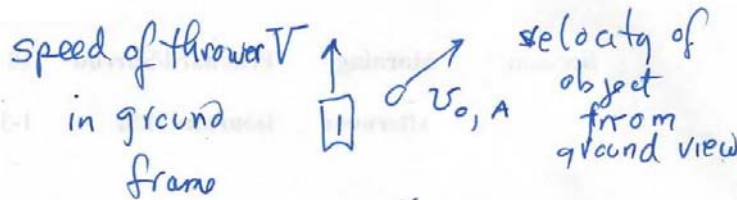
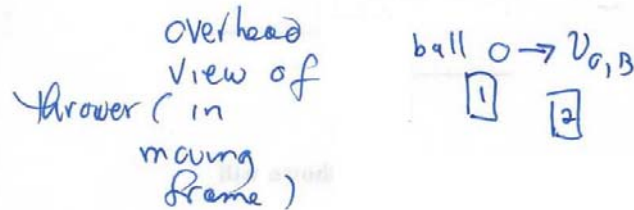
~~**Explain your answer.**~~

Exam 1 Solutions

Problem 1: (10 points) Concept Questions: Briefly answer the following questions.

a) (5 points) Two people are running forward at the same speed. One person throws a ball sideways to the other person at a constant speed v as seen by the thrower. Describe the motion of the ball as seen by a person standing on the ground. In particular according to the person on the ground is the ball moving faster, slower, or the same speed compared to the speed of the ball v as seen by the thrower?

Explain your answer:



In the ground frame, ball has a forward velocity component as well as sideways velocity component so speed is greater

$$v_{0,A} = ((v_{0,B})^2 + V^2)^{1/2}$$