

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

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Physics 8.01T

Fall Term 2004

Exam 1

Name _____

Section: Morning Pritchard/Surrow 10 - 12 _____

Afternoon Dourmashkin 1-3 _____

Table and Group: _____

The following exam consists of four problems. Answers without work shown will not be given any credit. Good luck!

Problem 1 (10 points)

Part a) (5 points) _____

Part b) (5 points) _____

Problem 2 (30 points) _____

Problem 3 (30 points) _____

Problem 4 (30 points) _____

Total (100 points) _____

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:

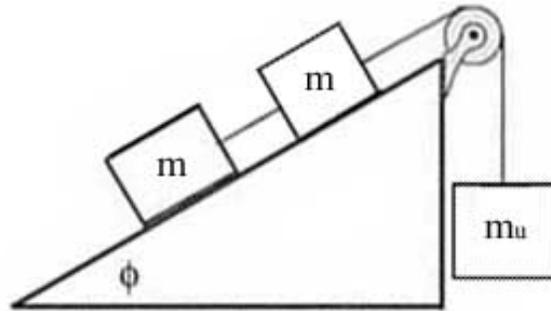
b) **(5 points)** You are standing on a spring bathroom scale in an elevator and look at the scale while the elevator is at rest with respect to the ground. In between floors, when the elevator is moving at a constant speed with respect to the ground, you look at the scale again. Does the scale show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

Explain your answer.

Part 2: Analytic Questions: Show all your work.

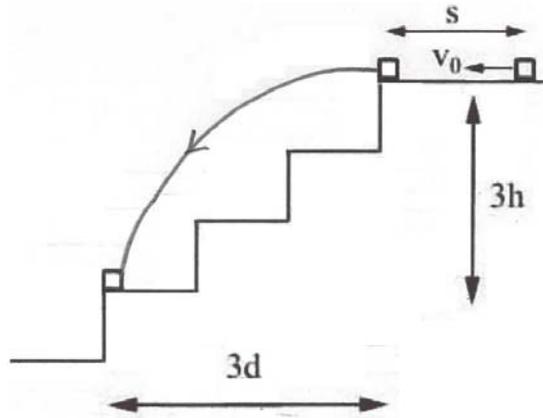
Problem 2: (30 points) Two identical blocks of given mass m , are attached together by a massless string and constrained to move along a plane that is inclined at a given angle ϕ to the horizontal. The upper block is connected via a second massless inextensible string that passes over a massless pulley, to a third block of unknown mass m_u . Assume the coefficient of static friction between the block and the inclined plane is given as μ_s and the coefficient of kinetic friction is given as μ_k . Assume the gravitational constant is given as g .

- a) What is the mass of the third block such that the blocks **just start slipping up** the inclined plane? Include in your answer a briefly explanation of how you intend to model this problem?
- b) Now suppose the string between the two identical blocks is cut. How does your model change? What are the accelerations of the lower block and the upper block on the inclined plane?



Answer:

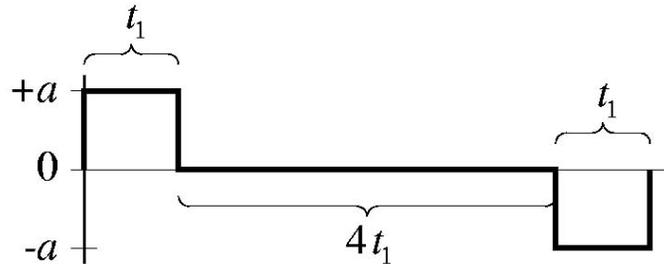
Problem 3: (30 points) An object of given mass m starts with a given velocity v_0 and slides an unknown distance s along a floor and then off the top of a staircase. The goal of this problem is to find the distance s . The coefficient of kinetic friction between the object and the floor is given by μ_k . The object strikes at the far end of the third stair. Each stair has a given rise of h and a given run of d . You may neglect air resistance and assume the gravitational constant is given as g .



- Briefly describe how you intend to model the motion of the object? What are the given quantities in this problem?
- What is the velocity of the object just as it leaves the top of the staircase? Express your answer in terms of the given quantities only.
- What is the acceleration of the object while it slides on the floor? Express your answer in terms of the given quantities only.
- What is the unknown distance s that the object slides along the floor? Express your answer in terms of the given quantities only.

Answer:

Problem 4: (30 points) A person of given mass m is standing on a scale in an elevator in Building 24. Initially the elevator is at rest. The elevator then begins to ascend to the sixth floor that is a given distance h above the starting point. The elevator undergoes an unknown constant acceleration a for a given time t_1 . Then the elevator moves at a constant velocity for a time $t_2 = 4t_1$. Finally the elevator brakes with a deceleration of the same magnitude as the initial acceleration for a time $t_3 = t_1$ until stopping at the sixth floor. Assume the gravitational constant is given as g . The goal of this problem is to find the magnitude of the acceleration and the readings on the scale.



- Briefly explain how you intend to model this problem.
- What is the magnitude of the acceleration and deceleration of the elevator? Express your answer in terms of the given quantities.
- When the elevator is accelerating upwards, what is the magnitude of the contact force between the person's feet and the scale?
- When the elevator is braking, what is the magnitude of the contact force between the person's feet and the scale?

Answer: