

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Physics

Physics 8.01

Spring 2005

WEEKLY QUIZ 3
Friday, February 18, 2005

Corrected Version, February 19, 2005: Added announcements made at the quiz

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FAMILY (LAST) NAME

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GIVEN (FIRST) NAME

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STUDENT ID NUMBER

Please check (✓) your class

	L01	MTW 10:00	Walter Lewin
	L02	MTW 11:00	Walter Lewin
	L03	MTW 2:00	Min Chen
	L04	MTW 3:00	Min Chen

INSTRUCTIONS:

1. The FORMULA SHEET is in the back of this exam. You may tear it off. There is also an extra BLANK PAGE in case you need it.
2. This is a closed book exam. CALCULATORS, BOOKS, and NOTES are NOT ALLOWED.
3. Unless otherwise stated, to earn full credit you must show a valid DERIVATION and/or EXPLANATION of your answer, and you must express it in terms of the GIVEN VARIABLES.

**ANNOUNCEMENTS MADE
AT THE QUIZ**

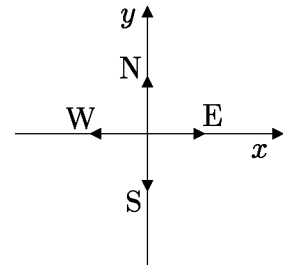
Problem 3(c): Remember that the rope has mass M and length ℓ .

Problem 4: Neglect the mass of the cables.

Problem	Maximum	Score	Grader
1	25		
2	25		
3	25		
4	25		
TOTAL	100		

Problem 1: Flying in the wind (25 points)

For this problem we will use a coordinate system in which the compass directions — North, South, East, and West — are oriented with respect to the x - and y -axes as shown on the right. Suppose that an airplane is traveling due east, at a speed v_{air} relative to the air. There is a wind blowing uniformly toward the south, at a speed v_{wind} .

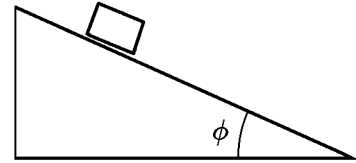


- (a) (6 points) What is the velocity \vec{v}_{ground} of the plane relative to the ground? Express your answer as a vector of the form $\vec{v}_{\text{ground}} = ?\hat{i} + ?\hat{j}$.
- (b) (6 points) What is the speed of the plane relative to the ground?
- (c) (6 points) What is the angle of the plane's ground velocity relative to east? Be sure to specify if the angle is north of east or south of east.
- (d) (7 points) Keeping the same speed relative to the air, v_{air} , the pilot turns the plane at just the right angle so that its velocity relative to the ground is due east. At what angle relative to east does he turn the plane? Be sure to specify if the angle is north of east or south of east.

Name _____

Problem 2: The inclined plane (*25 points*)

A block slides on a frictionless inclined plane, at an angle ϕ relative to the horizontal. Neglect air resistance.



- (a) (*8 points*) Draw a free body diagram showing all the forces acting on the block. Be sure to label each force.

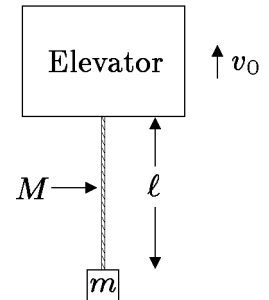
- (b) (*9 points*) What is the magnitude and direction of the acceleration that the block experiences?

- (c) (*8 points*) What is the magnitude and direction of the force that the inclined plane exerts on the block?

Name _____

Problem 3: A rope dangling from an elevator (25 points)

A rope of length ℓ and mass M is suspended from the bottom of an elevator. A block of mass m is attached to the bottom of the rope. For parts (a) and (b) of this problem, the elevator is moving upward at a uniform speed v_0 .

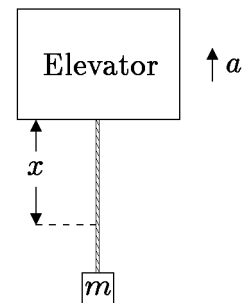


- (a) (8 points) What is the magnitude F of the force that the elevator applies to the top of the rope?

- (b) (8 points) What is the tension T_1 of the rope at its midpoint?

Now suppose that the elevator starts to accelerate upward at a fixed acceleration, of magnitude a .

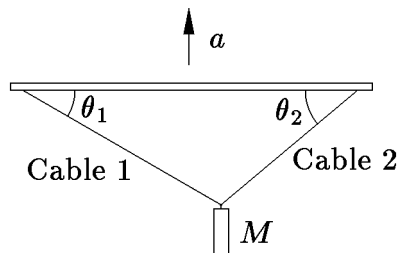
- (c) (9 points) What is the tension $T_2(x)$ in the rope at an arbitrary distance x below the elevator, where $0 \leq x \leq \ell$?



Name _____

Problem 4: Lifting by helicopter (25 points)

A steel block of mass M is being lifted by a helicopter, which is accelerating upward with an acceleration of magnitude a . The cylinder is attached to a horizontal bar by two cables, which make angles of θ_1 and θ_2 with respect to the horizontal, as shown in the diagram.



Find an expression for T_1 , the tension in cable 1, in terms of M , θ_1 , θ_2 , g , and a .

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QUIZ 3
FORMULA SHEET

Quiz Date: Friday, February 18, 2005

For motion in one dimension:

$$v_{\text{av}} = \frac{\Delta x}{\Delta t} \quad \text{Average velocity;}$$

$$v = \frac{dx}{dt} \quad \text{Instantaneous velocity;}$$

For motion in three dimensions:

$$\vec{v} = \frac{d\vec{r}}{dt}; \quad \vec{a} = \frac{d\vec{v}}{dt} = \frac{d^2\vec{r}}{dt^2}; \quad \vec{r}(t_1) = \vec{r}_0 + \int_0^{t_1} \vec{v} dt; \quad \vec{v}(t_1) = \vec{v}_0 + \int_0^{t_1} \vec{a} dt .$$

For *constant* acceleration \vec{a} , if $\vec{r} = \vec{r}_0$ and $\vec{v} = \vec{v}_0$ at time $t = 0$, then

$$\vec{v}(t) = \vec{v}_0 + \vec{a}t$$

$$\vec{r}(t) = \vec{r}_0 + \vec{v}_0t + \frac{1}{2}\vec{a}t^2 .$$

For one-dimensional motion with constant acceleration a :

$$v^2 = v_0^2 + 2a(x - x_0) .$$

For circular motion at constant speed v :

$$a = \frac{v^2}{r} ,$$

where r is the radius of the circle, and the acceleration is directed towards the center of the circle.

If an object has position \vec{r} and velocity \vec{v} , its position and velocity relative to an observer with position \vec{r}_0 and velocity \vec{v}_0 are given respectively by

$$\vec{r}' = \vec{r} - \vec{r}_0 , \quad \vec{v}' = \vec{v} - \vec{v}_0 .$$

Average velocity and acceleration are given by

$$\vec{v}_{\text{average}} = \frac{\Delta\vec{r}}{\Delta t} , \quad \vec{a}_{\text{average}} = \frac{\Delta\vec{v}}{\Delta t} .$$

Mass, Acceleration, and Force:

$$\vec{\mathbf{F}} = m\vec{\mathbf{a}} \quad (\text{Newton's second law});$$

$$\vec{\mathbf{F}} = -\frac{GMm}{r^2}\hat{\mathbf{r}} \quad (\text{the gravitational force between two particles});$$

$$\vec{\mathbf{F}} = \frac{1}{4\pi\epsilon_0} \frac{Qq}{r^2}\hat{\mathbf{r}} \quad (\text{the electrostatic force between two particles});$$

$$F_x = -kx \quad (\text{Hooke's law});$$

where $\hat{\mathbf{r}}$ is a unit vector pointing from the particle which is the source of the force, toward the particle on which the force is acting.