Name & ID ______________________________

UNIVERSITY OF ALABAMA
Department of Physics and Astronomy

PH 125 / LeClair | Spring 2009

Exam I

Instructions

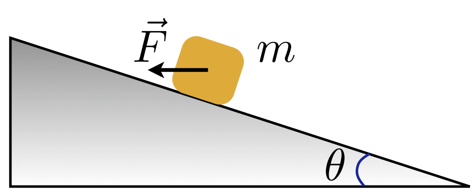
1. **Solve 4 of 8 problems below.**
2. Solve the problems on the template sheets provided. Attache other sheets as necessary.
3. All problems have equal weight.
4. You must answer all parts of multi-part questions for full credit.
5. Show your work for full credit. Significant partial credit will be given.
6. You are allowed 2 sides of a standard 8.5 x 11 in piece of paper with notes/formulas and a calculator.
7. You have 1h50m.

1. A pilot flies horizontally at 1300 km/h, at height $h = 35$ m above initially level ground. However, at time $t = 0$, the pilot begins to fly over ground sloping upward at angle $\theta = 4.3°$. If the pilot does not change the airplane's heading, at what time t does the plane strike the ground?

2. A ski jumper leaves the ski track moving in the horizontal direction with a speed of 35 m/s. The landing incline below falls off with a slope of $\varphi = 25°$ relative to horizontal. **(a)** How far down the slope does the skier land? **(b)** At what angle does the skier land with respect to the slope? (Greater fall and greater angle can result in loss of control in the landing.)

3. A batter hits a pitched ball when the center of the ball is 1.22 m above the ground. The ball leaves the bat at an angle of 45° with the ground. With that launch, the ball should have a horizontal range (returning to *launch* level) of 107 m. **(a)** Does the ball clear a 7.32 m-high fence that is 97.5 m horizontally from the launch point? **(b)** At the fence, what is the distance between the fence top and the ball center?

4. A crate of mass $m = 100$ kg is pushed at constant speed up a horizontal ramp ($\theta = 30°$) by a horizontal force $\vec{\mathbf{F}}$. What are the magnitudes of **(a)** $\vec{\mathbf{F}}$ and **(b)** the force on the crate from the ramp?



5. An elevator cab that weights 27.8 kN moves upward. What is the tension in the cable if the cab's speed is **(a)** increasing at a rate of 1.22 m/s^2 and **(b)** decreasing at a rate of 1.22 m/s^2?

6. A block of mass $m = 5.00$ kg is pulled along a horizontal frictionless floor by a cord that exerts a force of magnitude $F = 12.0$ N at an *upward* angle of 25°. **(a)** What is the magnitude of the block's acceleration? **(b)** The force magnitude F is slowly increased. What is its value just before the block is lifted (completely) off the floor? **(c)** What is the magnitude of the block's acceleration just before it is lifted (completely) off the floor?

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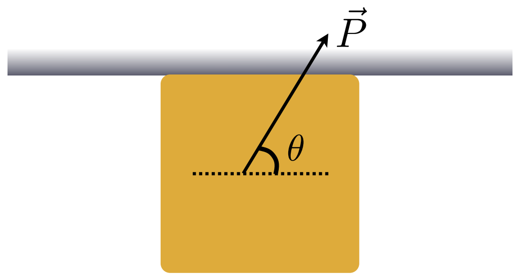
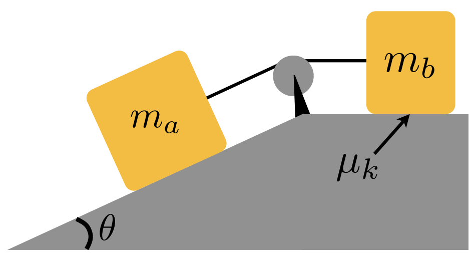
7. A student, crazed by exams, uses a force $\vec{\mathbf{P}}$ of magnitude $80\,\mathrm{N}$ and angle $70°$ to push a $5.0\,\mathrm{kg}$ block across the ceiling of his room. If the coefficient of kinetic friction between the block and the ceiling is 0.40, what is the magnitude of the block's acceleration?



8. Block A has mass $m_a = 4.0\,\mathrm{kg}$, and block B has mass $m_b = 2.0\,\mathrm{kg}$. The coefficient of kinetic friction between block B and the horizontal plane is $\mu_k = 0.50$. The inclined plane is frictionless, and at angle $\theta = 30°$. The pulley serves only to change the direction of the cord connecting the two blocks. The cord has negligible mass. Find **(a)** the tension in the cord and **(b)** the magnitude of the acceleration of the two blocks.



Formula sheet

$$g = 9.81\,\mathrm{m/s^2}$$

$$0 = ax^2 + bx^2 + c \Longrightarrow x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

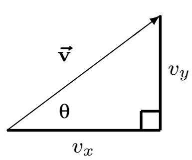
$$1\,\mathrm{N} = 1\,\mathrm{kg} \cdot \mathrm{m/s^2}$$

Vectors:

$$\begin{aligned}
\vec{\mathbf{a}} &= a_x\,\hat{\imath} + a_y\,\hat{\jmath} + a_z\,\hat{\mathbf{k}} \\
\vec{\mathbf{b}} &= b_x\,\hat{\imath} + b_y\,\hat{\jmath} + b_z\,\hat{\mathbf{k}} \\
|\vec{\mathbf{a}}| &= \sqrt{a_x^2 + a_y^2} \\
\tan\theta &= \frac{a_y}{a_x} \\
\vec{\mathbf{a}} + \vec{\mathbf{b}} &= (a_x + b_x)\,\hat{\imath} + (a_y + b_y)\,\hat{\jmath} + (a_z + b_z)\,\hat{\mathbf{k}} \\
\vec{\mathbf{a}} \cdot \vec{\mathbf{b}} &= a_x b_x + a_y b_y + a_z b_z \\
|\vec{\mathbf{a}} \cdot \vec{\mathbf{b}}| &= |\vec{\mathbf{a}}||\vec{\mathbf{b}}|\cos\varphi \\
|\vec{\mathbf{a}} \times \vec{\mathbf{b}}| &= |\vec{\mathbf{a}}||\vec{\mathbf{b}}|\sin\varphi \\
\vec{\mathbf{a}} \times \vec{\mathbf{b}} &= (a_y b_z - a_z b_y)\,\hat{\imath} + (a_z b_x - a_x b_z)\,\hat{\jmath} + (a_x b_y - a_y b_x)\,\hat{\mathbf{k}}
\end{aligned}$$

Right-hand rule for $x \times y = z$

1. Point the fingers of your right hand along the direction of x.
2. Point your thumb in the direction of y.
3. The direction of z is pointing out of the back of your hand.



$$\begin{aligned}
v_y &= |\vec{\mathbf{v}}|\sin\theta \\
v_x &= |\vec{\mathbf{v}}|\cos\theta \\
\tan\theta &= \tfrac{v_y}{v_x}
\end{aligned}$$

1-D motion:

$$\begin{aligned}
v(t) &= \frac{d}{dt}x(t) \\
a(t) &= \frac{d}{dt}v(t) = \frac{d^2}{dt^2}x(t)
\end{aligned}$$

const. acc. ↓

$$\begin{aligned}
x_f &= x_i + v_{xi}t + \frac{1}{2}a_x t^2 \\
v_f^2 &= v_i^2 + 2a_x\Delta x \\
v_f &= v_i + at
\end{aligned}$$

Projectile motion:

$$\begin{aligned}
v_x(t) &= v_{ix} = |\vec{\mathbf{v}}_i|\cos\theta \\
v_y(t) &= |\vec{\mathbf{v}}_i|\sin\theta - gt = v_{iy}\sin\theta - gt \\
x(t) &= x_i + v_{ix}t \\
y(t) &= y_i + v_{iy}t - \frac{1}{2}gt^2
\end{aligned}$$

over level ground:

$$\text{max height} = H = \frac{v_i^2 \sin^2\theta_i}{2g}$$

$$\text{Range} = R = \frac{v_i^2 \sin 2\theta_i}{g}$$

Force:

$$\begin{aligned}
\sum \vec{\mathbf{F}} &= \vec{\mathbf{F}}_{\text{net}} = m\vec{\mathbf{a}} \\
\sum F_x &= ma_x \\
\sum F_y &= ma_y \\
F_{\text{grav}} &= mg = \text{weight} \\
\vec{\mathbf{F}}_{12} &= -\vec{\mathbf{F}}_{21} \\
f_s &\le \mu_s n \\
f_{s,\text{max}} &= \mu_s n \\
f_k &= \mu_k n \\
\vec{\mathbf{F}}_{\text{drag}} &= -\frac{1}{2}C\rho A|\vec{\mathbf{v}}|\vec{\mathbf{v}} \\
\vec{\mathbf{F}}_c &= -\frac{mv^2}{r}\,\hat{\mathbf{r}}
\end{aligned}$$

2-D motion:

$$\begin{aligned}
\vec{\mathbf{r}} &= x(t)\,\hat{\imath} + y(t)\,\hat{\jmath} \\
x(t) &= x_i + v_{ix}t + \frac{1}{2}a_x t^2 \\
y(t) &= y_i + v_{iy}t + \frac{1}{2}a_y t^2 \\
\vec{\mathbf{v}} &= v_x(t)\,\hat{\imath} + v_y(t)\,\hat{\jmath} \\
v_x(t) &= \frac{dx}{dt} = v_{xi} + a_x t \\
v_y(t) &= \frac{dy}{dt} = v_{yi} + a_y t \\
\vec{\mathbf{a}} &= a_x(t)\,\hat{\imath} + a_y(t)\,\hat{\jmath} \\
a_x(t) &= \frac{dv_x}{dt} = \frac{d^2x}{dt^2} \\
\vec{\mathbf{a}}(t) &= \frac{d^2s}{dt^2}\,\hat{\mathbf{T}} + \kappa|\vec{\mathbf{v}}|^2\,\hat{\mathbf{N}} \\
&= \frac{d^2s}{dt^2}\,\hat{\mathbf{T}} + \frac{|\vec{\mathbf{v}}|^2}{R}\,\hat{\mathbf{N}} \equiv a_N\,\hat{\mathbf{T}} + a_T\,\hat{\mathbf{N}} \\
\vec{\mathbf{a}}_c &= -\frac{v^2}{r}\,\hat{\mathbf{r}} \quad \text{circ.} \\
T &= \frac{2\pi r}{v} \quad \text{circ.}
\end{aligned}$$

Power	Prefix	Abbreviation
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m
10^{-2}	centi	c
10^{3}	kilo	k
10^{6}	mega	M
10^{9}	giga	G
10^{12}	tera	T