University of Alabama
Department of Physics and Astronomy

PH 101 LeClair Summer 2011

Exam 1

Instructions

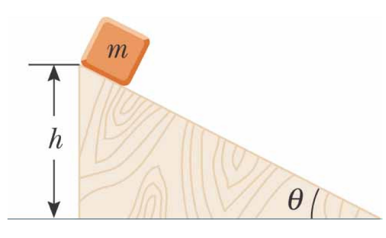
1. Solve five of the six problems below.
2. All problems have equal weight. Do your work on separate sheets.
3. You are allowed 1 sheet of standard 8.5×11 in paper and a calculator.

□ **1.** A motorcycle is following a car that is traveling at constant speed on a straight highway. Initially, the car and the motorcycle are both traveling at the same speed of 18 m/s, and the distance between them is 92.0 m. After 2.50 s, the motorcycle starts to accelerate at a rate of $4.00\,\mathrm{m/s^2}$. How long does it take from the moment the motorcycle starts to accelerate until it catches up to the car?

□ **2.** 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?

□ **3.** 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 angle of 65° with respect to horizontal. **(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 off the floor?

□ **4.** Consider the figure below. Let $h = 1$ m, $\theta = 15°$, and $m = 0.5$ kg. There is a coefficient of kinetic friction $\mu_k = 0.2$ between the mass and the inclined plane, and the mass m starts out at the very top of the incline with a velocity of $v_i = 0.1$ m/s. What is the speed of the mass at the bottom of the ramp?



□ **5.** A baseball leaves the bat at 30.0° above the horizontal and is caught by an outfielder 375 ft from home plate at the same height from which it left. What is the initial speed of the ball?

□ **6.** An advertisement claims that a particular automobile can "stop on a dime." What net force would actually be necessary to stop a 850 kg automobile traveling initially at 45.0 km/h in a distance equal to the diameter of a dime, which is 1.8 cm. *Hint: watch the units!*

Formula sheet

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

$$1\,\mathrm{km/h} = \frac{5}{18}\,\mathrm{m/s} \approx 0.2778\,\mathrm{m/s}$$

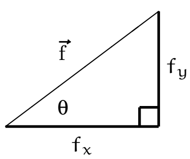
$$1\,\mathrm{km} = 1000\,\mathrm{m}$$

$$1\,\mathrm{cm} = 0.01\,\mathrm{m}$$

$\downarrow$ quadratic formula:

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

Generic vector $\vec{f}$:



$$f_y = |\vec{f}| \sin\theta$$
$$f_x = |\vec{f}| \cos\theta$$
$$\tan\theta = \frac{f_y}{f_x}$$
$$|\vec{f}| = \sqrt{f_x^2 + f_y^2}$$

1-D motion, constant acceleration:

$$\overline{v} = \frac{x_2 - x_1}{t_2 - t_1} = \frac{\Delta x}{\Delta t}$$
$$\overline{a} = \frac{v_2 - v_1}{t_2 - t_1} = \frac{\Delta v}{\Delta t}$$
$$v(t) = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t}$$
$$a(t) = \lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t}$$
$$x_f = x_i + v_{xi} t + \frac{1}{2} a_x t^2$$
$$v_{xf}^2 = v_{xi}^2 + 2 a_x \Delta x$$
$$v_f = v_i + a t$$

2-D motion, constant acceleration:

$$\vec{r} = x(t)\,\hat{\imath} + y(t)\,\hat{\jmath}$$
$$x(t) = x_i + v_{ix} t + \frac{1}{2} a_x t^2$$
$$y(t) = y_i + v_{iy} t + \frac{1}{2} a_y t^2$$
$$v_x(t) = v_{xi} + a_x t$$
$$v_y(t) = v_{yi} + a_y t$$

Quantity	Unit	equivalent to
force	N	kg·m/s^2
acceleration	m/s^2	-
velocity	m/s	-
position	m	-

Projectile motion:

$$v_x(t) = v_i \cos\theta_o$$
$$x(t) = x_i + (v_i \cos\theta_o)\, t$$
$$v_y(t) = v_i \sin\theta_o - g t$$
$$y(t) = y_i + (v_i \sin\theta_o)\, t - \frac{1}{2} g t^2$$

$\downarrow$ over level ground:

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

$\downarrow$ launch at $y = 0$:

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

$\downarrow$ launched from origin

$$y(x) = (\tan\theta_o)\, x - \frac{g x^2}{2 v_o^2 \cos^2\theta_o}$$

Force in general:

$$\Sigma\vec{F} = \vec{F}_{\mathrm{net}} = m\vec{a}$$
$$\Sigma F_x = m a_x$$
$$\Sigma F_y = m a_y$$
$$\vec{F}_{12} = -\vec{F}_{21}$$

Particular forces:

$$F_{\mathrm{gravity}} = m g = \text{weight}$$

$$\text{friction} \begin{cases} f_s & \leqslant \mu_s n \\ f_{s,\mathrm{max}} & = \mu_s n \\ f_k & = \mu_k n \end{cases}$$

$$F_{\mathrm{spring}} = -k \Delta x$$

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