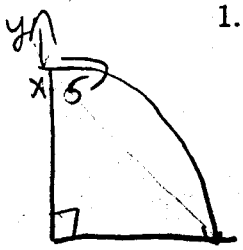
In all problems, neglect air resistance and take $\boxed{g = 9.80\,\text{m/s}}$, unless stated otherwise.

A. [25 points; **show the details of your calculations**; put a box around each final answer.]

A ball is thrown horizontally, with a **speed** of 5.0 m/s, from the edge of the top of a building, and later strikes the (level) ground with a **speed** of 13.0 m/s. *(Note: Compared to other similar problems you might have seen, the order of the steps to solve this problem might seem "backwards". Answer these questions in the order asked.)*



1. [5 points] What is the horizontal component of the velocity just before the ball strikes the ground?

$V = V_x + V_y$ 5 m/s

5

2. [5 points] What is the vertical component of the velocity just before the ball strikes the ground?

13 m/s

12

0

3. [5 points] For how long was the ball in the air?

$y = y_0 - v_{y0}t + \frac{1}{2}gt^2$

$v_f = v_i + at$ $x = x_0 + v_{x0}t + \frac{1}{2}a_x t$

0

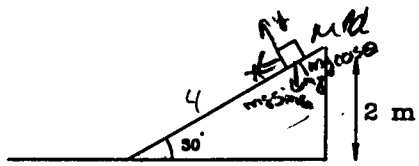
4. [5 points] How far from the base of the building did the ball strike the ground?

0

5. [5 points] How high is the building?

0

B. [25 points; **show the details of your calculations**; put a box around each final answer.] A small block starts from rest at a **height** of 2.0 m on an inclined plane which makes an angle of $\theta = 30°$ with the horizontal. The coefficient of kinetic friction between the block and incline is 0.40.



1. [5 points] In the space adjacent to the figure, draw a free-body diagram for the block; draw all of the forces acting on the block, carefully indicating the direction of each force.

2. [8 points] Calculate the acceleration of the block, beginning from Newton's laws.

$F = ma$

$mg\sin\theta - \mu N = ma$

$g\sin\theta - \mu = a$

$9.8\sin 30 - .4 = a$

$a = 4.5\ m/s^2$

3. [5 points] How fast is the block going as it reaches the end of the incline?

$\sin 30° = \frac{2}{x}$ $\quad x = 4m$ $\quad v_f^2 = v_i^2 + 2a(x_f - x_i)$

$v_f = v_i + at$ $\quad v_f^2 = 2(4.5)(4)$

$v_f = at$ $\quad v_f = 6\ m/s$

$v_f = 4.5t$

4. [7 points] If the block continues to slide on the horizontal ground with the same coefficient of friction, how far does it slide before coming to rest?

$F = ma$

$mg\sin\theta - \mu N = ma$ $\quad f_k = .4(9.8) = 3.92$

$3.92 = m(4.5)$

$m = .87$

C. Multiple-choice questions [30 pts. (5 pts. each)]

Each question should be solvable by simply identifying the correct principle and/or equation(s). Write down the appropriate equation(s) and solve, and circle the correct solution. If an incorrect answer is circled, some partial credit will be awarded if the appropriate work is written **clearly, coherently, and completely** in the space adjacent to the the multiple-choice answers.

If a multiple-choice question takes you more than about 2 minutes, move on, do the other multiple-choice questions and the two long problems, and come back to it later. Pace yourself.

1. A ball is thrown vertically upward with an initial speed of 19.6 m/s. How long does it take to reach its maximum height?

$y_f - y_i = v_i t + \frac{1}{2} a t^2$

$y_f = 19.6t + t$

$v_f = v_i + at$

$= 8 + 9.8(2)$

(a) 4.0 s
(b) 2.0 s
(c) 1.0 s
(d) 0.5 s
(e) Cannot be determined from the information provided.

2. The position, as a function of time, of a projectile is given as

$$x = 15.0\,\text{m} + (6.0\,\text{m/s})t$$
$$y = 30.0\,\text{m} + (8.0\,\text{m/s})t - (4.9\,\text{m/s}^2)t^2$$

$30 + 16 - 19.6$

What is the speed of the projectile at $t = 2.0$ s?

$30 + 8(2) - 4.9(2)^2$

$\sqrt{(15+12)^2 + (30+16+19.6)^2}$

$\frac{\Delta y}{\Delta t} = \frac{15+12}{30+16-19.6}$

(a) 13.1 m/s
(b) 12.0 m/s
(c) 11.6 m/s
(d) 10.0 m/s
(e) 8.0 m/s
(f) 6.0 m/s

3. Two forces $\vec{F}_1 = 6.0\,\text{N}\hat{\imath}$ and $\vec{F}_2 = |\vec{F}_2|\hat{\jmath}$ act on a 20.0 kg object which accelerates with an acceleration of magnitude 0.5 m/s^2. Note that the direction of the second force $\vec{F}_2$ is given. What is the magnitude, $|\vec{F}_2|$, of this second force?

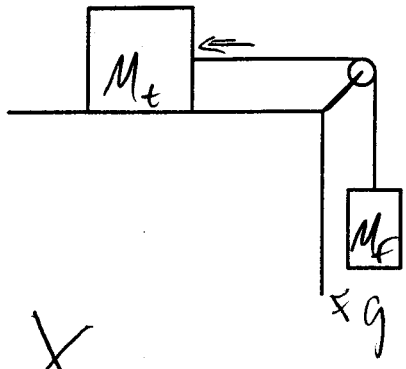
$F_1 + F_2 = ma$

$6 + F_2 = 20(.5)$

$r^2 = 4^2 + 6^2$

(a) 10.0 N
(b) 8.0 N
(c) 6.0 N
(d) 3.0 N
(e) 0
(f) Cannot be determined from the information provided.

4. A hanging block is connected by a massless unstretchable string (which passes around a massless frictionless pulley) to another block which is free to slide on a flat **frictionless** horizontal table. Compare the tension in the string where it connects to the block on the table to the weight of the hanging block.



$M_f \cdot g = M_t \cdot a$

(a) tension < weight
(b) tension = weight
(c) tension > weight

5. In an inertial reference frame, a person holds a spring-meter scale from which hangs a a weight. The reading on the spring-meter scale is 60 N. Then the weight and scale are accelerated upwards with an acceleration of magnitude $g/3$. What is the new reading of the spring-meter scale?

(a) 0 N
(b) 30 N
(c) 45 N
(d) 60 N
(e) 80 N

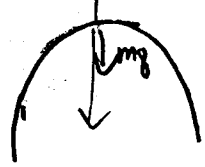
$60 = m\frac{9.8}{3}$

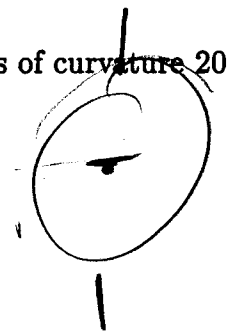
$\frac{9.8}{3}$

$\sum F_y = F_g + m\frac{9.8}{3} = 60 + \frac{60}{9.8}\left(\frac{9.8}{3}\right)$

6. A 1000 kg car travels at 10 m/s over the top of a hill of radius of curvature 20 m. What is the magnitude of the total normal force on the car?

(a) 0
(b) 4.8×10^3 N
(c) 9.8×10^3 N
(d) 14.8×10^3 N





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D. Multiple (T)rue/(F)alse Questions [20 pts. (2 pts. each)]

For each of the statements following the leading statement, circle whether the statement is true or false. (There may be any number of true (or false) responses for each leading statement. Each T/F response is worth 2 points. No partial credit will be awarded for an incorrect response.)

If any T/F response takes you longer than about a minute, move on, and come back to it later. Pace yourself.

1. An object undergoes one-dimensional motion.

X (T) or F If the acceleration is negative, then necessarily the object is slowing down.

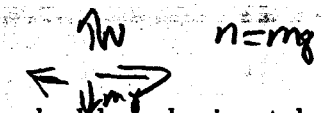
$v = \frac{\Delta x}{\Delta t}$ ✓ (T) or F If the average velocity for some time interval is zero, then the displacement for that time interval is zero.

X (T) or F If a constant acceleration is non-zero, then the instantaneous velocity can never equal zero.

2. A coin rests on the upper surface of a book which I hold horizontally. I release the book from rest and it falls straight down, such that the book's upper surface remains horizontal. While the book is falling

✓ (T) or F The frictional force on the coin is zero.

✓ T or (F) The normal force on the coin is numerically equal to its weight.



3. A book is pushed by a horizontal applied force, and slides at constant velocity across a horizontal table.

X T or (F) The vector sum of all forces on the book is zero.

✓ T or (F) The frictional force and the applied force are a "Newton's third law pair", that is, they are equal and opposite because of Newton's third law.

✓ T or (F) The normal force on the book and the weight of the book are a "Newton's third law pair", that is, they are equal and opposite because of Newton's third law.

4. As a car travels around an **unbanked** (i.e. not tilted) circular curve on a rough road at constant speed.

X T or (F) The total static frictional force on the car's tires is numerically equal to the net force on the car.

✓ T or (F) The net force on the car is directed outward away from the center of the circle.