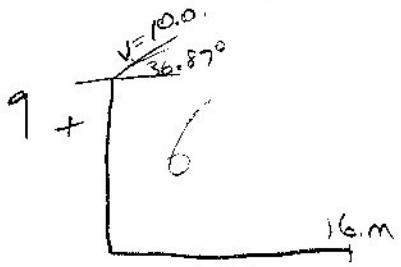
In all problems, neglect air resistance and take $g = 9.80\,\text{m/s}^2$, unless stated otherwise.

A. [30 points; **show the details of your calculations**; put a box around each final answer.]

A ball is thrown, at an angle of 36.87° above the horizontal, with a **speed** of 10.0 m/s, from the edge of the top of a building, and later strikes the (level) ground a distance of 16.0 m from the base of the building. (Choose upwards to be positive.)

25

1. [6 points] What is the horizontal component of the velocity just before the ball strikes the ground?



9 +

$v_f = v_i + at$

$= 10\frac{m}{s}\cos 36.87° + 0$

$= 8.00\frac{m}{s}$

6

2. [8 points] For how long was the ball in the air?

8

$t = \frac{d}{v_i \cos\theta}$

$= \frac{16}{10\cos 36.87°}$

$= 2.00\,s$

3. [8 points] What is the vertical component of the velocity just before the ball strikes the ground? (Remember upwards is positive.)

8

$v_{fy} = v_{iy} + at$

$= 10\frac{m}{s}\sin(36.87) - 9.8\frac{m}{s^2}(2)s$

$= -13.6\frac{m}{s}$

4. [8 points] How high is the building?

3

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

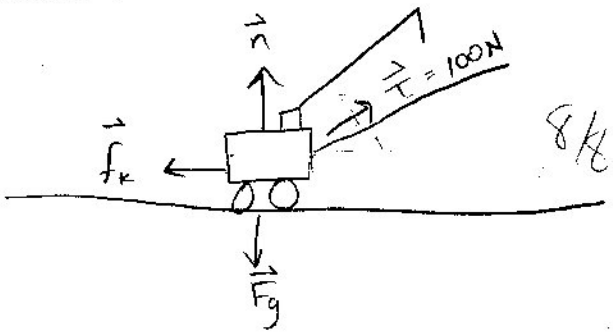
$= 0 + 10\frac{m}{s}\sin(36.87)(2s) + \frac{1}{2}[(-9.8)2^2]\,m$

$= 27.2\,m$

X

B. [30 points; **show the details of your calculations**; put a box around each final answer!]
A 20 kg crate is pulled to the right across a rough level horizontal floor by a rope with tension 100 N inclined at an angle of 36.87° above the horizontal. The crate accelerates to the right with magnitude 0.5 m/s^2.

1. [8 points] Draw a free-body diagram for the crate, showing clearly the directions of all appropriate forces.



8/8

2. [6 points] Determine the net force (direction and magnitude) on the crate.

$\sum F_x = \vec{T}\cos\theta - \vec{f}_k = ma = 0.5\frac{m}{s^2} \cdot 20 \cos 36.87 = 8.00\ N$

$\sum F_y = \vec{n} + T\sin\theta - F_g = 0$

$\sum F = 20 \cdot .05 =$ 10 N → to the right

6/6

3. [8 points] Determine the frictional force (direction and magnitude).

$f_k = ma - T\cos\theta = 70.0\ N$ to the left

8/8

4. [8 points] Determine the normal force on the crate (direction and magnitude).

$20 \cdot 9.8\frac{m}{s^2} = 196 - 100\sin 36.87 = 136N$ up

8/8

13

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.

L=h
t=n

1. Inhabitants of the planet Xenon measure lengths with the unit "hmmm" (denoted h) and time with the unit "nyuk" (denoted n). Zygorb drops a rock from a height of 24.0 h and it takes 4.0 n to hit the ground. Neglecting air friction (which is a very good approximation on Xenon) what is the magnitude of the acceleration due to gravity on Xenon?

~~(a) 9.8 n/h²~~
(b) 9.8 h/n²
~~(c) 3.0 n/h²~~
5 (d) 3.0 h/n²
~~(e) 12.0 n/h²~~
(f) 12.0 h/n²

$a = \frac{h}{s^2}$ or $\frac{h}{n^2}$ 24.0 m, 4.0 s

$= \frac{24h}{(4n)^2} \cdot 2 = 3$

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

$$x = 15.0\,\text{m} + (6.0\,\text{m/s})t - (2.0\,\text{m/s}^2)t^2$$
$$y = 30.0\,\text{m} - (8.0\,\text{m/s})t - (1.5\,\text{m/s}^2)t^2$$

$V = 6.0\frac{m}{s} - 2(2.0\frac{m}{s^2})t$

What is the x-**component** of the **average velocity** of the car during the interval from $t = 0.0\,\text{s}$ to $t = 2.0\,\text{s}$?

$\frac{V(0)+V(2)}{2} = \frac{6+(-2)}{2} = 2$

(a) +4.0 m/s
(b) +3.0 m/s
5 (c) −2.0 m/s
(d) 0.0 m/s
(e) −2.0 m/s
(f) −3.0 m/s
(g) −4.0 m/s

3. A plane moving initially due north at 132 km/hr moves into a region where the wind is blowing at 100 km/hr to the direction 36.87° north of east. What is the speed of the plane with respect to the ground?

(a) 232 km/hr
B (b) 212 km/hr
(c) 208 km/hr
(d) ~~192 km/hr~~
(e) 166 km/hr
(f) 32 ~~km/hr~~

$\sqrt{(132\,\text{km/hr} + 100\sin 36.87)^2 + (100\cos 36.87)^2}$ ✓

4. What constant force is required to accelerate a 2000 kg race car from rest to a speed of 50 m/s over a distance of 100 m.

(a) 100 kN
(b) ~~50 kN~~
(c) 25 kN
(d) 10 kN

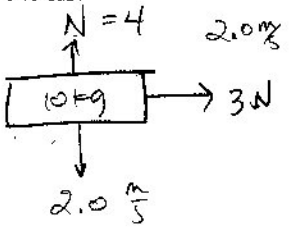
F, v, d

$$\frac{v_f^2 - v_i^2}{2((x_f - x_i))} = a = \frac{(50^2)\frac{m^2}{s^2}}{100\,m} = 25\,\frac{m}{s^2}$$

$$F = ma = 2000 \cdot 25\,\frac{m}{s^2} = 50{,}000\ N$$

5. A 10 kg wooden block is dragged, at a constant velocity of 2.0 m/s southward, across a rough wooden table by two horizontal strings. One string pulls the block northward with a force of magnitude 4.0 N, the other eastward with a force of magnitude 3.0 N. What is the magnitude of the force of friction on the block?

(a) 0
(b) 1.0 N
(c) 2.0 N
(d) 5.0 N
(e) 7.0 N
(f) Cannot be determined, since we are not told the coefficient of friction.



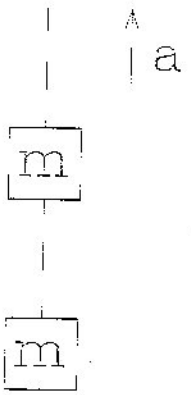
6. A person of mass m stands on the floor of an elevator which is accelerating downwards with an acceleration of magnitude $g/3$. What is the magnitude of the normal force exerted on the person by the floor?

(a) $(4/3)\,mg$
(b) mg
(c) $(2/3)\,mg$
(d) ~~$(1/3)\,mg$~~
(e) $0\,mg$

$$mg - \frac{mg}{3} = ma \qquad mg\,\frac{3}{3}$$

2

7. Two objects with equal mass m are connected by strings in the manner shown. The system is accelerated upwards with acceleration $g/5$. What is the tension in the string which connects the two blocks together?



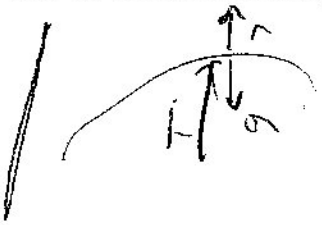
(a) $(12/5)mg$
(b) $(10/5)mg$
(c) $(8/5)mg$
(d) $(6/5)mg$
(e) $(5/5)mg$
(f) $(4/5)mg$
(g) $(3/5)mg$
(h) $(2/5)mg$
(i) $(1/5)mg$
(j) 0

$F = 2m\frac{g}{5}$

$\Sigma F = m\frac{g}{5} + mg = m\frac{4g}{5}$

8. An object of mass 10.0 kg is attached to a rope and swung in a **vertical** circle of radius 0.500 m. What is the magnitude of the tension in the rope when the object is at the **top** of the circle and moves with an instantaneous speed of 3.00 m/s?

(a) 0 N
(b) 82 N
(c) 98 N
(d) 180 N
(e) 278 N



$F_r = 10 \cdot \frac{(3)^2}{0.5} = 180\ N$