Possibly helpful information for the test:
$\pi = 3.14159$
Air resistance may be neglected in all problems

MULTIPLE CHOICE (16 points total)

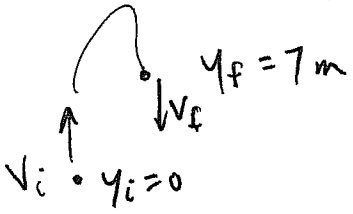
1. A sheet of metal is known to be exactly square. You make a measurement of the length of one of its sides to be $x = 33.30$ cm $\pm$ 0.05 cm. What is the best way to write the measured area of the square? [You may use the equation Area $= x^2$.]

   (A) 1109 ± 3 cm^2
   B. 1109 ± 2 cm^2
   C. 1108.89 ± 0.05 cm^2
   D. 1110 ± 80 cm^2
   E. 1108.9 ± 0.3 cm^2

   $\Delta A = 2x\,\Delta x$ (Power Rule)
   $= 2(33.3)(0.05)$
   $\Delta A = 3$ cm^2
   $A = x^2 = 1108.89$: round to ones place to match error : $A = 1109$ cm^2

2. Chad throws a ball straight up. Nicole watches the ball from a balcony 7.0 m above where Chad released it. The ball passes Nicole on the way up, and it has a speed of 15 m/s as it passes her again on the way back down. How fast did Chad throw the ball?

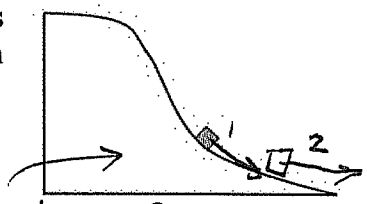
   (A) 19 m/s
   B. 14 m/s
   C. 9.4 m/s
   D. 84 m/s
   E. 49 m/s

   $v_f^2 = v_i^2 + 2a_y(y_f - y_i)$
   $v_i = \left[v_f^2 + 2g y_f\right]^{1/2} = \left[15^2 + 2(9.8)7\right]^{1/2}$
   $v_i = 19$ m/s

3. A cart slides without friction down a track as shown. As the cart slides beyond the point shown, what happens to its acceleration in the direction of motion and its speed?

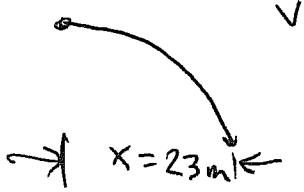
   A. Both increase.
   (B) The speed increases, but the acceleration decreases.
   C. Both remain constant.
   D. The speed decreases, but the acceleration increases.
   E. Both decrease.

   Speeds up.
   but $a = g\sin\theta$ decreases, because θ decreases

4. A ball thrown horizontally at 14 m/s travels a horizontal distance of 23 m before hitting the ground. From what height was the ball thrown?

   (A) 13 m
   B. 20 m
   C. 26 m
   D. 30 m
   E. 49 m

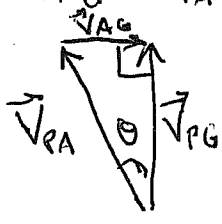
   $v_x = \frac{x}{t}$, $t = \frac{x}{v_x}$
   $y = \frac{1}{2}gt^2 = \frac{1}{2}g\left(\frac{x}{v}\right)^2$
   $= \frac{1}{2}(9.8)\left(\frac{23}{14}\right)^2 = 13.2$ m

5. The airspeed indicator on an airplane shows that it is moving through the air at 240 km/hr. According to the weather report, there is a 110 km/hr wind moving from west to east. In what direction should the pilot head in order to travel due north?

   (A) 27° West of North
   B. 25° West of North
   C. 27° East of North
   D. 25° East of North
   E. 62° West of North

   $v_{PA} = 240$
   $\vec{v}_{AG} = 110$, E

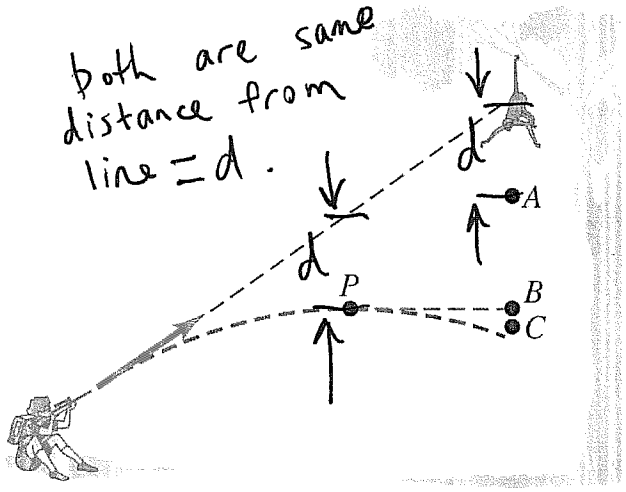
   $\vec{v}_{PG} = \vec{v}_{PA} + \vec{v}_{AG}$ $\vec{v}_{PG}$ is North

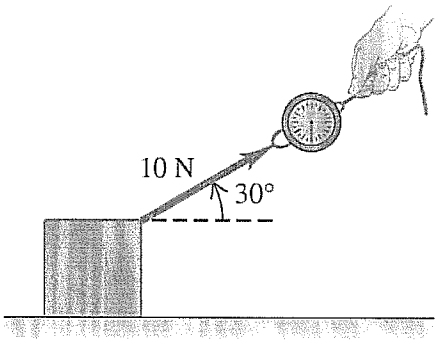
   $\sin\theta = \frac{v_{AG}}{v_{PA}}$
   $\theta = \sin^{-1}\left(\frac{110}{240}\right) = 27^\circ$ W of N.

6. A monkey is hanging from a high branch in a tree. A zookeeper aims a tranquilizer dart gun directly at the monkey. At the moment the tranquilizer dart is released from the gun, its initial velocity is directly toward the monkey. However, at that same moment, the monkey lets go of the branch, and begins falling. Unfortunately for the zookeeper, the initial speed of the dart is too low, so it reaches a maximum height at a point P before striking the monkey, as shown in the figure. When the dart is at point P, where will the monkey be?

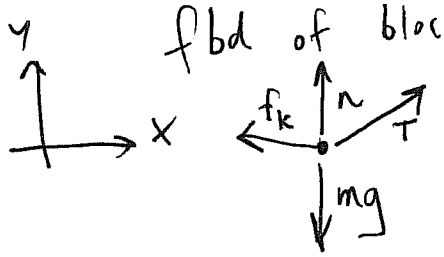
(A.) Point A, higher than P
B. Point B, at the same height as P
C. Point C, lower than P



7. A 1 kg block is pulled along a flat concrete surface with a constant force of 10 N, directed 30° above the horizontal, as shown. The block is sliding to the right, and the coefficient of kinetic friction between the block and the concrete surface is 0.62. What is the acceleration of the block?



A. 9 m/s^2, to the right
(B.) 6 m/s^2, to the right
C. 3 m/s^2, to the right
D. zero
E. 3 m/s^2, to the left



	x	y
n	0	n
T	$T\cos\theta$	$T\sin\theta$
mg	0	$-mg$
f_k	$-\mu_k n$	0

$F_{Net y} = 0$
$\Rightarrow n = mg - T\sin\theta$

$F_{Net y} = n + T\sin\theta - mg$

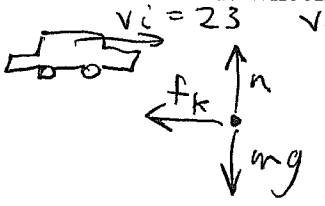
$F_{Net x} = T\cos\theta - \mu_k n$

$F_{Net x} = ma_x = T\cos\theta - \mu_k(mg - T\sin\theta)$

$a_x = \frac{1}{1\,kg}[10\cos 30 - 0.62(9.8 - 10\sin 30)] = 5.68\ m/s^2$

8. A 1200 kg car is traveling at a speed of 23 m/s on a level road. Suddenly, the driver sees a deer and slams on the brakes, locking all four wheels. The car skids to a halt. Determine the distance the car travels between the instant the wheels lock, and when it finally stops. Assume the coefficient of kinetic friction between the wheels and the road is $\mu_k = 0.80$.

A. 2.9 m
B. 27 m
C. 28 m
(D.) 34 m
E. 57 m



$F_{Net} = ma_x = -f_k = -\mu_k n = -\mu_k mg$

$a_x = -\mu_k g$

$F_{Net y} = 0 \Rightarrow n = mg$

$v_f^2 = v_i^2 + 2ax$

$x = \frac{v_i^2}{2\mu_k g} = \frac{23^2}{2(0.8)(9.8)} = 34\ m$

FREE-FORM IN TWO UNRELATED PARTS (12 points total)

Clearly show your reasoning and work as some part marks may be awarded. Write your final answers in the boxes provided.

PART A

Two sign-posts are located a distance of $d = 25.0 \pm 0.5$ m apart. You and your friend watch cars driving along the road, and you use a stop-watch to measure the time it takes them to drive the distance between the sign-posts. You make the following five measurements for five different cars:

$t_1 = 1.85$ s $\quad t_2 = 1.81$ s $\quad t_3 = 1.88$ s $\quad t_4 = 1.77$ s $\quad t_5 = 1.83$ s

(i) 4 points — What is the estimated mean time for cars to drive the distance between the sign posts? [Please write your final answer in the box provided. Express your error to one significant figure, and make sure the most precise tenth place of the value matches the tenth place of the error.]

$$x_{avg} = \frac{1.85+1.81+1.88+1.77+1.83}{5} = 1.828\ s.$$

$$\sigma_{est} = \left[\frac{1}{4}\left((1.85-1.828)^2+(1.81-1.828)^2+(1.88-1.828)^2+(1.77-1.828)^2+(1.83-1.828)^2\right)\right]^{1/2}$$

$$\sigma_{est} = 0.041 .$$

Error in the mean is $\frac{\sigma_{est}}{\sqrt{N}} = \frac{0.041}{\sqrt{5}} = 0.0185$

1 or 2 sig figs.

Most precise tenth place of error must match most precise tenth place of value.

$t = 1.828 \pm 0.019$ s
or 1.83 ± 0.02 s .

(ii) 3 points — Assume the cars are traveling at constant velocity. Use your value of estimated mean time to find the estimated mean speed of cars on this road. [Please write your final answer in the box provided. Express your error to one significant figure, and make sure the most precise tenth place of the value matches the tenth place of the error.]

Constant velocity $\Rightarrow v = \frac{d}{t} = \frac{25}{1.828} = 13.676$ m/s.

error, use product rule:

$$\Delta v = v\sqrt{\left(\frac{\Delta d}{d}\right)^2+\left(\frac{\Delta t}{t}\right)^2} = 13.676\sqrt{\left(\frac{0.5}{25}\right)^2+\left(\frac{0.019}{1.828}\right)^2}$$

$$\Delta v = 0.308\ m/s .$$

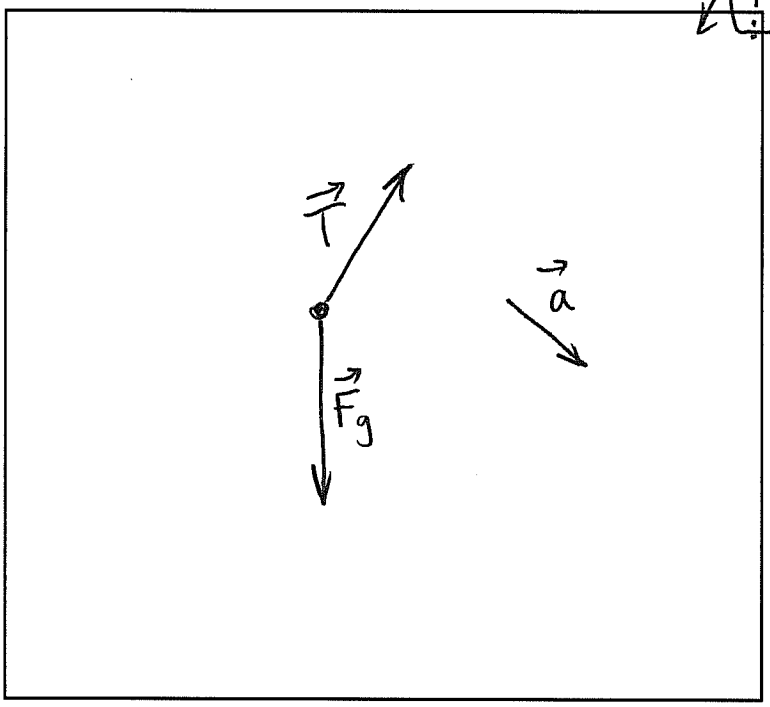
1 or 2 sig figs.

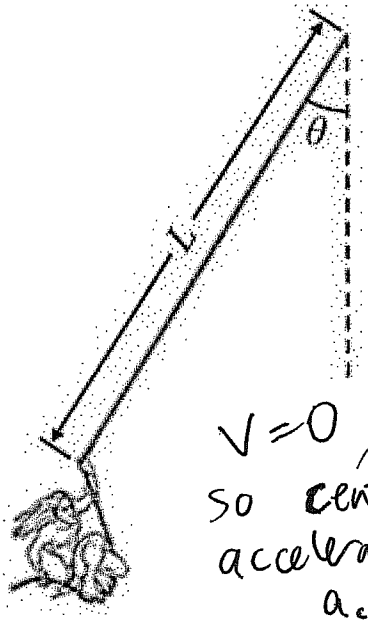
$v = 13.68 \pm 0.31$ m/s
or 13.7 ± 0.3 m/s .

PART B

Tarzan swings from a rope of length $L = 7.5$ m, as shown. The other end of the rope is attached to a fixed branch. At the instant shown, the angle of the rope relative to the vertical is $\theta = 32°$, and Tarzan is momentarily at rest. In the box provided, sketch a free-body diagram for Tarzan, showing and labeling all the forces acting on him at this moment. Near the free-body diagram, and also in this box, add a vector, labeled $\vec{a}$, showing the correct direction of Tarzan's acceleration at this moment. If Tarzan has a mass of 82 kg, what is the magnitude of the tension in the rope at this instant? 5 points

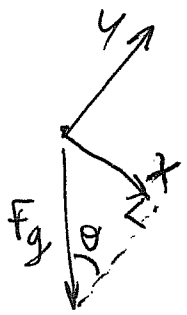
Free-body diagram and acceleration vector of Tarzan: 2 for fbd.





$v = 0$ so centripetal acceleration $a_c = 0$.

$\Rightarrow \vec{a}$ must be tangential,



Define $+y$ along $\vec{T}$

$+x$ perpendicular to rope in direction of acceleration (tangent).

	x	y
T	0	T
F_g	$mg\sin\theta$	$-mg\cos\theta$
	$F_{net,x} = mg\sin\theta$	$(F_{net})_y = ma_y = 0 = T - mg\cos\theta$

$\Rightarrow T = mg\cos\theta = (82)(9.8)\cos 32$

$T = 680$ N

$T = 680$ N

3 points