110 Spring 2019 Test 1A Once the exam has officially started, remove the top sheet. The remaining sheets comprise your exam. It is each student's individual responsibility to ensure the instructor has received her or his completed exam. Any exams not received by the instructor earn zero points. Smart watches, phones, or other devices (except scientific calculators) are not permitted during the exam.

$V_{sphere} = \frac{4}{3}\pi R^3$	$V_{box} = LWH$	$V_{cyl} = \pi R^2 H$	$\rho = \frac{M}{V}$
$A_{sphere} = 4\pi R^2$	$V = (A_{base}) \times (height)$	$A_{circle} = \pi R^2$	$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$
$C = 2\pi R$	$A_{rect} = LW$	$A_{CylSide} = 2\pi RH$	
$160\underline{9}\ \text{m} = 1\ \text{mi}$	$12\ \text{in} = 1\ \text{ft}$	$60\ \text{s} = 1\ \text{min}$	$1000\ \text{g} = 1\ \text{kg}$
$2.54\ \text{cm} = 1\ \text{in}$	$1\ \text{cc} = 1\ \text{cm}^3 = 1\ \text{mL}$	$60\ \text{min} = 1\ \text{hr}$	$100\ \text{cm} = 1\ \text{m}$
$1\ \text{cm} = 10\ \text{mm}$	$1\ \text{yard} = 3\ \text{ft}$	$3600\ \text{s} = 1\ \text{hr}$	$1\ \text{km} = 1000\ \text{m}$
$1\ \text{furlong} = 220\ \text{yards}$	$528\underline{0}\ \text{ft} = 1\ \text{mi}$	$24\ \text{hrs} = 1\ \text{day}$	$1\ \text{rev} = 2\pi\ \text{rad} = 360°$
$g = 9.8\ \frac{\text{m}}{\text{s}^2}$	$G = 6.67 \times 10^{-11} \frac{\text{N}\cdot\text{m}^2}{\text{kg}^2}$	$P_0 = 1.0 \times 10^5\ \text{Pa}$	$1\ \text{eV} = 1.60\underline{2} \times 10^{-19}\ \text{J}$
$1\ \text{N} = 1 \frac{\text{kg}\cdot\text{m}}{\text{s}^2}$	$1\ \text{J} = 1\ \text{N}\cdot\text{m}$	$1\ \text{Pa} = 1\ \frac{\text{N}}{\text{m}^2}$	
$x_f = x_i + v_{ix}t + \frac{1}{2}a_x t^2$	$v_{fx}^2 = v_{ix}^2 + 2a_x(\Delta x)$	$v_{fx} = v_{ix} + a_x t$	$r = \sqrt{x^2 + y^2}$
$\vec{A}\cdot\vec{B} = AB\cos\theta_{AB}$	$\lVert\vec{A}\times\vec{B}\rVert = AB\sin\theta_{AB}$	$\sin(A \pm B)$ $= \sin A\cos B \pm \cos A \sin B$	$\cos(A \pm B)$ $= \cos A\cos B \mp \sin A\sin B$
$\vec{v}_{ae} + \vec{v}_{eb} = \vec{v}_{ab}$	$\hat{r} = \cos\theta\,\hat{\imath} + \sin\theta\,\hat{\jmath}$	$\hat{\theta} = -\sin\theta\,\hat{\imath} + \cos\theta\,\hat{\jmath}$	
$a_{tan} = r\alpha$	$a_c = \frac{v^2}{r} = r\omega^2$	$\vec{a} = a_r\hat{r} + a_{tan}\hat{\theta}$	$\vec{a} = a_c(-\hat{r}) + a_{tan}\hat{\theta}$
$\Sigma\vec{F} = m\vec{a}$	$f \leq \mu n$		

Prefix	Abbreviation	$10^?$		Prefix	Abbreviation	$10^?$
Giga	G	10^9		milli	m	10^{-3}
Mega	M	10^6		micro	μ	10^{-6}
kilo	k	10^3		nano	n	10^{-9}
centi	c	10^{-2}		pico	p	10^{-12}
				femto	f	10^{-15}

$[\text{M}] = \text{mass} = \text{kg}$ $\quad [\text{L}^2] = \text{area} = \text{m}^2$ $\quad [\text{T}] = \text{time} = \text{s}$ $\quad \left[\frac{\text{L}}{\text{T}^2}\right] = \text{acceleration} = \frac{\text{m}}{\text{s}^2}$

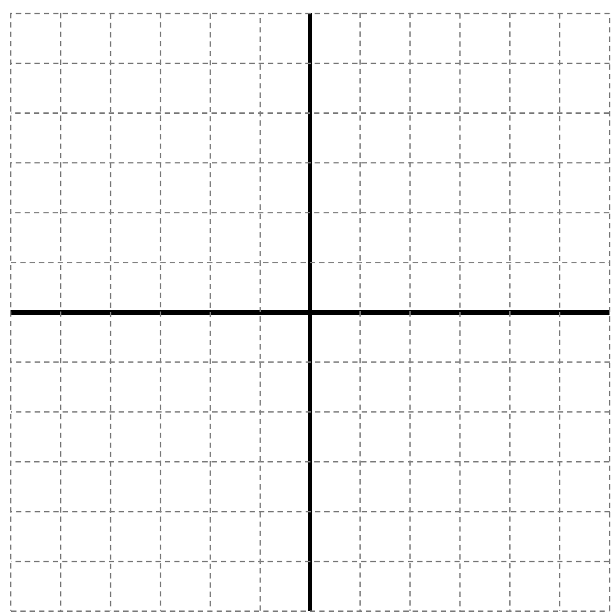
$[\text{L}] = \text{length} = \text{m}$ $\quad [\text{L}^3] = \text{volume} = \text{m}^3$ $\quad \left[\frac{\text{L}}{\text{T}}\right] = \text{velocity} = \frac{\text{m}}{\text{s}}$ $\quad \left[\frac{\text{L}\cdot\text{M}}{\text{T}^2}\right] = \text{force} = \frac{\text{kg}\cdot\text{m}}{\text{s}^2} = \text{N}$

NAME: ______________________________

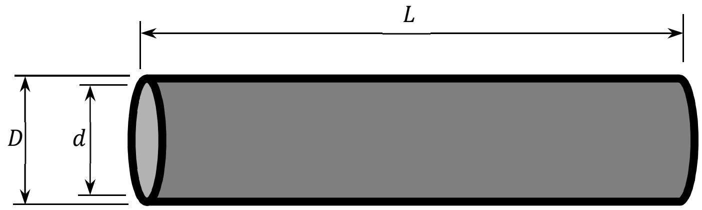
The first page includes almost 40% of the possible points.
I estimate you should budget about 35 minutes for this page.
Said another way: don't freak out if you spend half the test period on page 1…

The vector $\vec{z}$ has magnitude 4.44 m angled at 55.5° west of south.
A second vector is $\vec{w} = (3.33\hat{\imath} - 2.22\hat{\jmath})$ m.
**1a) Express the vector $\vec{z}$ in *Cartesian* form.
**1b) Express the *unit* vector $\hat{w}$ in *Cartesian* form.
**1c) Express $\vec{w}$ in *polar* form.
**1d) Determine the *magnitude* of $\vec{z} \times \vec{w}$.
**1e) Determine the *angle* between $\vec{w}$ and the negative x-axis.
**1f) Sketch $\vec{z}$ & $\vec{w}$ *to scale* on the grid provided.
Each vector must be labeled to receive points.

1a	
1b	
1c	
1d	
1e	



A carbon nanotube is constructed by rolling an ultra-thin sheet of graphene into the shape of a pipe.
The nanotube has outer diameter $D = 7.77$ nm and inner diameter $d = 7.43$ nm.
The length of the tube is $L = 44.4$ cm.
The tube density is $\rho = 2.267 \times 10^6 \frac{\text{g}}{\text{m}^3}$.
Believe it or not, these parameters could be realistic!
Figure not to scale.



***2a) Determine an ALGEBRAIC EXPRESSION for the *mass* of the tube in terms of $\rho, d, D, \& L$. Simplify your work to ensure full credit.
***2b) Determine a NUMERICAL VALUE for the tube *mass*.

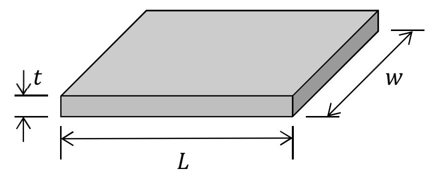
- Use *engineering* notation with appropriate choice of prefix.
- Get the sig figs correct.

2a	
2b	

3

**3) Convert $8.88\,\frac{\text{ng}}{\text{day}^2}$ to $\frac{\text{lbs}}{\text{yr}^2}$. Write your final answer in *scientific* notation.
Note: near earth's surface one generally assumes $1\text{ lbs} = 453.\underline{6}$ g.

A slab has dimensions $L = 4.44 \times 10^{-1}$ m, $w = 880$ mm, & $t = 0.00500$ m.
Figure not to scale.



4a) Determine the number of sig figs of w.
4b) Write w using units of m in correct scientific notation (with correct sig figs).
4c) Determine the number of sig figs for t.
4d) Write L in *engineering* notation with appropriate prefix (and correct sig figs).

4a
4b
4c
4d

***5) You are told an equation exists such that

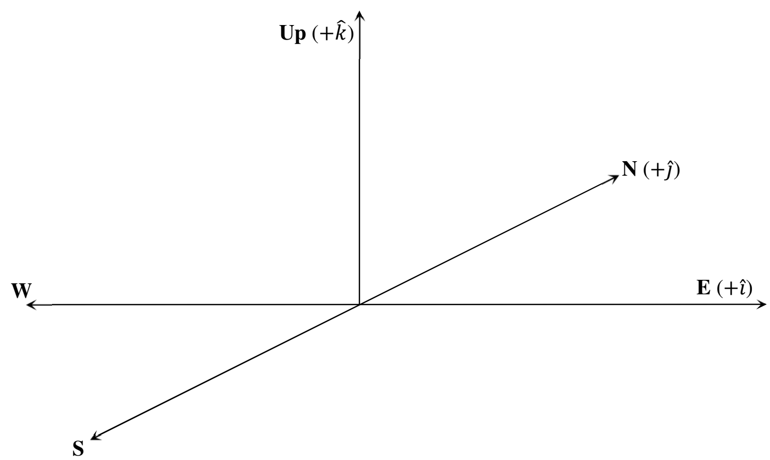
$$k = \frac{vt}{x^2 a}$$

where x is position (same units as distance), v is velocity, t is time, a is acceleration, and k is an unknown constant.
Determine the units appropriate for the unknown constant k.

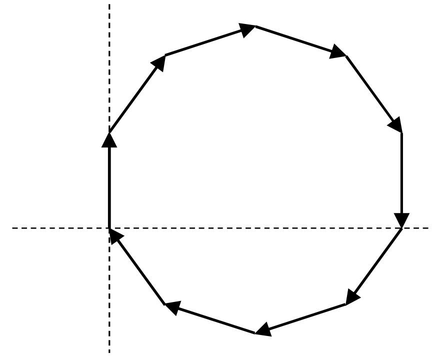
5

6	

*****6) A drone undertakes three displacements.
During the 1st displacement the drone moves 22.22 m due south.
During the 2nd displacement it moves 33.33 m directed 33.33° north of east.
After the 3rd displacement, the drone is located 11.11 m above of its starting point.
Determine the *magnitude* of the 3rd displacement.
Include units and 3 sig figs on your final answer.
An empty coordinate system is provided in case you find that useful…
A correct sketch (with each vector labeled) *may* help with partial credit.
To be clear, the sketch is NOT *required* for full credit.



Extra credit: An engineer wishes to program a sentry robot to travel along the 10-sided path shown. This shape is called a regular 10-gon (regular decagon). The robot starts at the origin. Each of the 10 displacements has identical length. At the end of each displacement, the robot rotates through some angle then continues with the next displacement. The engineer requires maximum horizontal displacement from the origin to be 3.33 m. Determine the required magnitude of each displacement.



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