161 Fall 2025 Test 1B 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.

$V_{sphere} = \frac{4}{3}\pi R^3$	$V_{box} = LWH$	$V_{cyl} = \pi R^2 H$	$\rho = \frac{M}{V}$
$A_{sphere} = 4\pi R^2$	$V = (A_{base}) \times (height)$	$A_{circle} = \pi R^2$	$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$
$C = 2\pi R$	$A_{rect} = LW$	$A_{CylSide} = 2\pi RH$	
$160\underline{9}\text{ m} = 1\text{ mi}$	$12\text{ in} = 1\text{ ft}$	$60\text{ s} = 1\text{ min}$	$1000\text{ g} = 1\text{ kg}$
$2.54\text{ cm} = 1\text{ in}$	$1\text{ cc} = 1\text{ cm}^3 = 1\text{ mL}$	$60\text{ min} = 1\text{ hr}$	$100\text{ cm} = 1\text{ m}$
$1\text{ cm} = 10\text{ mm}$	$1\text{ yard} = 3\text{ ft}$	$3600\text{ s} = 1\text{ hr}$	$1\text{ km} = 1000\text{ m}$
$1\text{ furlong} = 220\text{ yards}$	$528\underline{0}\text{ ft} = 1\text{ mi}$	$24\text{ hrs} = 1\text{ day}$	$1\text{ rev} = 2\pi\text{ rad} = 360°$
$g = 9.8\ \frac{\text{m}}{\text{s}^2}$	$G = 6.67 \times 10^{-11}\frac{\text{N}\cdot\text{m}^2}{\text{kg}^2}$	$P_0 = 1.0 \times 10^5\text{ Pa}$	$1\text{ eV} = 1.60\underline{2} \times 10^{-19}\text{ J}$
$1\text{ N} = 1\frac{\text{kg}\cdot\text{m}}{\text{s}^2}$	$1\text{ J} = 1\text{ N}\cdot\text{m}$	$1\text{ Pa} = 1\ \frac{\text{N}}{\text{m}^2}$	$m_e = 9.11 \times 10^{-31}\text{ kg}$
$x_f = x_i + v_{ix}t + \frac{1}{2}a_x t^2$	$v_{fx}^2 = v_{ix}^2 + 2a_x(\Delta x)$	$v_{fx} = v_{ix} + a_x t$	$r = \sqrt{x^2 + y^2}$
$\vec{A}\cdot\vec{B} = AB\cos\theta_{AB}$	$\lVert\vec{A}\times\vec{B}\rVert = AB\sin\theta_{AB}$	$\sin(A \pm B)$ $= \sin A\cos B \pm \cos A\sin B$	$\cos(A \pm B)$ $= \cos A\cos B \mp \sin A\sin B$
$\vec{v}_{ae} + \vec{v}_{eb} = \vec{v}_{ab}$	$\hat{r} = \cos\theta\,\hat{\imath} + \sin\theta\,\hat{\jmath}$	$\hat{\theta} = -\sin\theta\,\hat{\imath} + \cos\theta\,\hat{\jmath}$	
$a_{tan} = r\alpha$	$a_c = \frac{v^2}{r} = r\omega^2$	$\vec{a} = a_r\hat{r} + a_{tan}\hat{\theta}$	$\vec{a} = a_c(-\hat{r}) + a_{tan}\hat{\theta}$
$\Sigma\vec{F} = m\vec{a}$	$f \le \mu n$	$F_G = \frac{GmM}{r^2}(-\hat{r})$	$U_G = -\frac{GmM}{r}$
$TKE = \frac{1}{2}mv^2$	$RKE = \frac{1}{2}I\omega^2$	$U_S = SPE = \frac{1}{2}kx^2$	$U_G = GPE = mgh$
$E_i + W_{\substack{non-con \\ or\ ext}} = E_f$	$\Delta KE = W_{ext.\&\,non-con}$	$W = Fd\cos\theta = F_{\parallel}d$	$W = \int F_x dx$
$\Delta U = -W = -\int_i^f \vec{F}\cdot d\vec{s}$	$F_x = -\frac{d}{dx}U(x)$	$\mathcal{P}_{inst} = \frac{dE}{dt} = \vec{F}\cdot\vec{v}$	$\mathcal{P}_{avg} = \frac{\Delta E}{\Delta t} = \frac{Work}{time}$
$\vec{J} = \Delta\vec{p} = \vec{F}\Delta t$	$\vec{p} = m\vec{v}$	$x_{\text{CM}} = \frac{m_1x_1 + m_2x_2}{m_1 + m_2}$	$x_{\text{CM}} = \frac{\int x\,dm}{\int dm}$
$\vec{\tau} = \vec{r}\times\vec{F}$	$\Sigma\vec{\tau} = I\vec{\alpha}$	$L = I\omega = mvr_{\perp}$	$\mathcal{P}_{inst} = \vec{\tau}\cdot\vec{\omega}$
$s = r\Delta\theta$	$v = r\omega$	$a_{tan} = r\alpha$	$a_c = \frac{v^2}{r} = r\omega^2$
$I_{\parallel axis} = I_{\text{CM}} + md^2$	$I_{zz} = I_{xx} + I_{yy}$	$I = \int r^2 dm$	$\frac{F}{A} = E\frac{\Delta L}{L_0}$
$P = \frac{F}{A}$	$P_{gauge} = P_{abs} - P_{ambient}$	$B = \rho_f V_{disp} g$	$A_1v_1 = A_2v_2$
$P(h) = P_0 + \rho gh$	$P + \frac{1}{2}\rho v^2 + \rho gh = \text{constant}$	$R = \frac{\pi r^4\Delta P}{8\eta L}$	$F = \eta A\frac{\Delta v_x}{\Delta y}$

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}

Name:____

For this problem, assume we can model the basketball as a thin spherical shell of uniform density material. A basketball has mass $568\ \mathrm{g}$. To be clear, this mass includes the air inside the ball as well as the material used to make up the thin spherical shell. The ball has *outer circumference* $72.4\ \mathrm{cm}$. The *inner diameter* of the spherical shell is $228.1\ \mathrm{mm}$. The density of air inside the ball is $1.795\,\frac{\mathrm{kg}}{\mathrm{m}^3}$.

For this problem all answers should have correct sig figs.

The figure is my attempt to show inside the ball so you can see it has slightly different inner & outer radii.

1a) Determine the outer diameter of the ball in units of mm.

1b) Determine this *air density* in units of $\frac{\mathrm{g}}{\mathrm{cm}^3}$. **Answer in *scientific* notation.**

**1c) Determine the mass of air inside the ball in units of g.

**1d) Determine the density of the material used to make the ball.

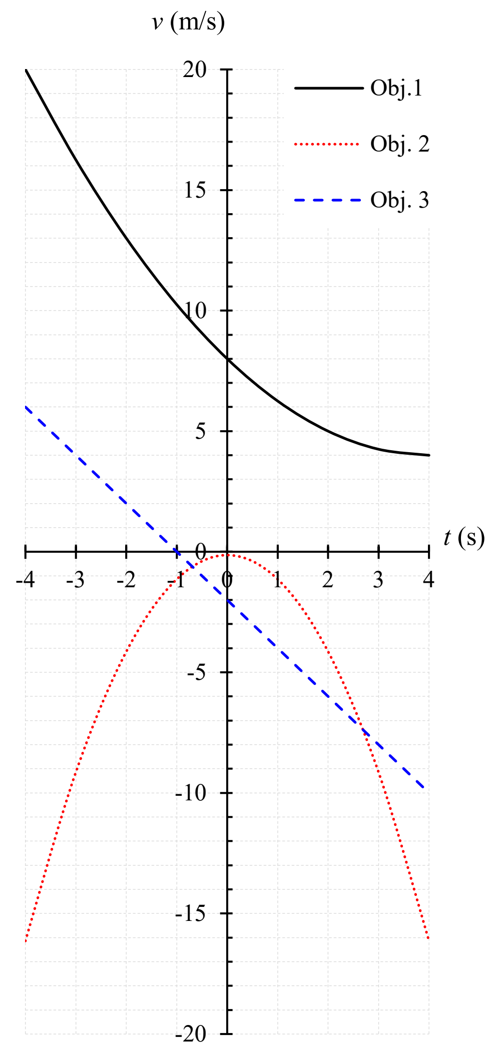
Do this part of problem after finishing the rest of the test; it was time-consuming for 2 points.

1a	
1b	
1c	
1d Do last	

Plots of 1D motion for three objects are shown at right.

For any vector answers on *this* page, it is ok to leave off the $\hat{\imath}$.

Also, two sig figs will suffice for answers on this page.



2a) Determine acceleration of object 1 at time $t = 0.00$ s.

2b) Which objects (if any) experience *positive* total displacement over the entire time interval (from $t = -4.00$ s to $t = +4.00$ s)?

2c) Determine *distance traveled* by object 3 during the entire time interval (from $t = -4.00$ s to $t = +4.00$ s)?

2d) At what times (or during which time intervals) is object 3 at rest? If no such time exists, state "never occurs".

2e) Which best describes the motion of object 3 over the entire time interval shown? Circle the best answer.

Moving *forwards* the entire time	Moving *backwards* the entire time	First moves *forwards* then *backwards*	First moves *backwards* then *forwards*	Impossible to determine without more info	None of the other answers is correct

2f) Which best describes the motion of object 3 over the entire time interval shown? Circle the best answer.

Speeding up the entire time	*Slowing down* the entire time	First *speeds up* then *slows down*	First *slows down* then *speeds up*	Impossible to determine without more info	None of the other answers is correct

For the rest of the test, round final answers in each box to *three* sig figs.
Exception: you can include *four* sig figs if the first digit in a result is 1.

A displacement vector is $\vec{r} = \left(-6.00\hat{\imath} + 5.00\hat{\jmath} + 4.00\hat{k}\right)$ m.
A force vector is $\vec{F} = (-3.00\hat{\jmath})$ N.

3a) Determine the *magnitude* of vector $\vec{r}$.

3b) Determine the angle between $\vec{r}$ and the positive x-axis. Express your result as a number between 0° and 180°.

***3c) Torque is defined as $\vec{\tau} = \vec{r} \times \vec{F}$. Determine torque using the given vectors.
Answer in Cartesian form with components in the standard order.

3a	
3b	
3c	

An equation for force (F) is $F = Pv^{727} - \frac{3}{4}Q\sqrt{\frac{\pi m a}{v x}}$ where Q & P are constants.
Here m is mass, x is position, v is velocity, & a is acceleration. Force has units of $\mathrm{N} = \mathrm{kg} \cdot \frac{\mathrm{m}}{\mathrm{s}^2}$.

**4) Determine the units assumed on the constant Q in terms of kg, m, and s.
Simplify your work as much as possible to receive credit. It's a bit ugly.

4	

A ball is thrown upwards (purely vertical motion) from a diving platform with speed v. While not strictly true, assume the ball experiences constant acceleration *after* impact (while travelling underwater). Assume the constant underwater acceleration accounts for all forces (includes buoyant force, drag, and gravity). The *magnitude* of the underwater acceleration is $3g$. The ball reaches max depth d below the pool's surface (assume purely vertical motion). Assume this problem uses a standard coordinate system ($+\hat{j}$ is upwards) with negligible air resistance.

5a) Which best describes the acceleration of the ball during freefall? Circle the best answer.

Negative on the way up then positive on the way down	Zero on the way up then positive on the way down	Negative on the way up then zero on the way down	Always negative	Impossible to determine without more info
Positive on the way up then negative on the way down	Zero on the way up then negative on the way down	Positive on the way up then zero on the way down	Always positive	None of the other answers is correct

5b) While the ball is in freefall, which best describes the time spent travelling upwards versus downwards?

Same amount of time travelling upwards and downwards	More time spent travelling upwards	More time spent travelling downwards	Impossible to determine without more info	None of the other answers is correct

*****5c) Determine initial height of the ball (above the pool's surface) at the instant it was thrown.

Simplify the final result to ensure full credit!

A quality sketch with clear labels is worth a point!

5c	

A particle moving along the x-axis has initial velocity $-v_0$. The particle has acceleration given by

$$a = +kv^3$$

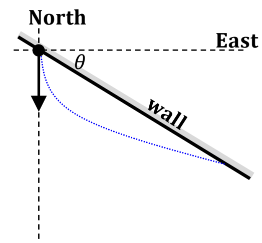
where k is a positive constant.

6a) Determine the units assumed for the constant k.

***6b) Determine an expression for velocity as a function of time. **Simplify your result for full credit.**

6a	
6b	

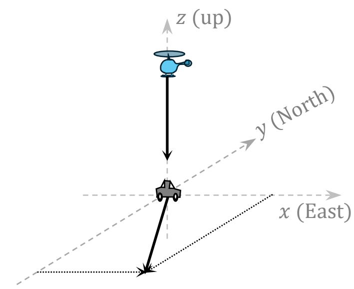
The figure at right does <u>not</u> show a projectile! The figure shows a top view of a drone flying near a wall (thick black line at angle θ south of east). The drone is initially at the origin *heading south* with speed v. The drone accelerates *to the east* at constant rate a.



******7) Determine the distance between the origin and the impact location.
Simplify your result to ensure full credit.

7	

At one instant in time a helicopter is $275\ \text{m}$ directly above a car. At this instant, the helicopter is moving *downwards* (relative to earth) with constant speed.
Relative to the earth, the car drives with speed $22.2\,\frac{\text{m}}{\text{s}}$ heading $30.0°$ east of south.
Relative to the helicopter, the car's speed is $32.50\,\frac{\text{m}}{\text{s}}$. **Figure not to scale.**



*8a) Write the velocity of the car (relative to earth) in Cartesian form using the given coordinate system and figure.

***8b) Determine the speed of the helicopter *relative to earth*.

**8c) Determine the direction of the car's velocity *relative to the helicopter*.
State the direction as a unit vector in Cartesian form with components in the standard order.

8a	
8b	
8c	

Page intentionally left blank as scratch paper.