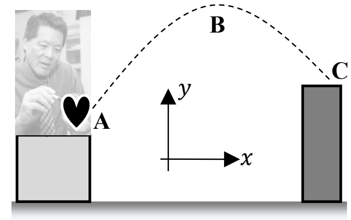
161 Spring 2024 Test 1A Once the exam has officially started, remove the top sheet. The remaining sheets comprise your exam. It is each student's individual responsibility to ensure the instructor has received her or his completed exam. Any exams not received by the instructor earn zero points. Smart watches, phones, or other devices (except scientific calculators) are not permitted during the exam.

$V_{sphere} = \frac{4}{3}\pi R^3$	$V_{box} = LWH$	$V_{cyl} = \pi R^2 H$	$\rho = \frac{M}{V}$
$A_{sphere} = 4\pi R^2$	$V = (A_{base}) \times (height)$	$A_{circle} = \pi R^2$	$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$
$C = 2\pi R$	$A_{rect} = LW$	$A_{CylSide} = 2\pi RH$	
$160\underline{9}$ m = 1 mi	12 in = 1 ft	60 s = 1 min	1000 g = 1 kg
2.54 cm = 1 in	1 cc = 1 cm^3 = 1 mL	60 min = 1 hr	100 cm = 1 m
1 cm = 10 mm	1 yard = 3 ft	3600 s = 1 hr	1 km = 1000 m
1 furlong = 220 yards	$528\underline{0}$ ft = 1 mi	24 hrs = 1 day	1 rev = 2π rad = 360°
$g = 9.8\ \frac{\text{m}}{\text{s}^2}$	$G = 6.67 \times 10^{-11} \frac{\text{N}\cdot\text{m}^2}{\text{kg}^2}$	$P_0 = 1.0 \times 10^5$ Pa	1 eV = $1.60\underline{2} \times 10^{-19}$ J
$1\ \text{N} = 1 \frac{\text{kg}\cdot\text{m}}{\text{s}^2}$	1 J = 1 N·m	$1\ \text{Pa} = 1 \frac{\text{N}}{\text{m}^2}$	$m_e = 9.11 \times 10^{-31}$ 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:____



Len Miyahara flicks a model heart directed 45° above the horizontal. Point **A** indicates *just after* the heart left Len's hand. The heart then reaches max height at point **B**. Point **C** indicates *just before* impact. For ease of communication, call the *horizontal* velocity components $v_{\mathbf{A}x}$, $v_{\mathbf{B}x}$, and $v_{\mathbf{C}x}$, at points **A**, **B**, & **C** respectively. Similarly, call the vertical velocity components $v_{\mathbf{A}y}$, $v_{\mathbf{B}y}$, and $v_{\mathbf{C}y}$, at points **A**, **B**, & **C** respectively. Air resistance is negligible. Figure not to scale, but you may assume point **C** is higher than point **A**. A coordinate system is indicate for clarity.

1a) Specifically state *all* velocity components which should be zero. Clearly indicate both location and the component (i.e. $v_{\mathbf{A}x}$ or $v_{\mathbf{A}y}$) for all such points. If none are equal to zero, write "none are equal to zero".

1b) Rank the *vertical* velocity components from smallest (most negative) to greatest (most positive) clearly indicating any ties. **Note: zero is larger than any negative number for this problem.**

1c) Rank the *horizontal* velocity components from smallest (most negative) to greatest (most positive) clearly indicating any ties. **Note: zero is larger than any negative number for this problem.**

1d) At which point or points does the heart have greatest *speed*? If there is a tie, list all points with greatest speed.

1e) At which point or points does the heart have greatest *acceleration*? If there is a tie, list all points with greatest acceleration.

2a) Velocity equations for four different particles are given in the table shown at right. To which of these particles, if any, does the standard kinematics formula $\Delta x = \frac{1}{2}a_x t^2 + v_{ix}t$ apply?

Particle **A**	$v = 6t^2 - 4t + 2$
Particle **B**	$v = 3$
Particle **C**	$v = -7t + 1$
Particle **D**	$v = 9t^3$

2b) In order to be dimensionally correct, what units must be used for the number 6 in the equation for particle **A** shown in the table?

3) A US shipping ton is equivalent to $40.00\ \text{ft}^3$. How many US shipping tons are obtained from $333\ \text{m}^3$? **Answer in scientific notation with appropriate sig figs.**

3	

4) Answer the following subtraction problem with **correct significant figures and **correct engineering notation with appropriate prefix**.

$$1.023 \times 10^6\ \text{s} - 998700\ \text{s} = ?$$

4	

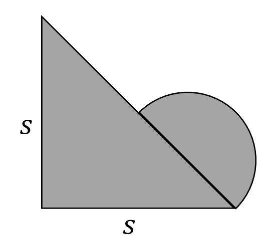
**5) A made-up physics equation states that

$$mg = \frac{kmd}{t} - \frac{t^3}{d^5 c^2}$$

where m is mass, g is the magnitude of the acceleration due to gravity, d is distance, and t is time. Here k & c are unknown positive constants. Determine the appropriate units for c.

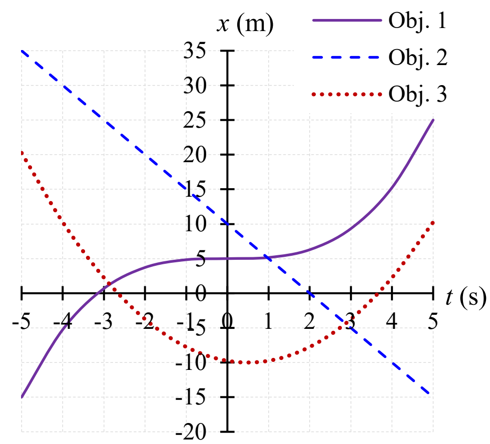
5	

6) A flat plate is made from a right triangular piece of metal with density ρ. The plate has thickness t (into the page) and side lengths s. A semi-circular plate made of the same material has diameter equal to half the hypotenuse of the triangle is welded to the triangle as shown. **Determine total mass as a number with 3 sig figs times an expression involving $\boldsymbol{\rho}, \boldsymbol{s}$, & $\boldsymbol{t}$.



6	

Plots of three objects in 1-dimensional motion are shown at right.



7a) When is **object 1** at rest? If never at rest, answer "NEVER".

7b) Which objects (if any) experience no acceleration? If all objects experience acceleration, answer "NONE".

7c) Between times $t = -5.0$ s and $t = 0.0$ s, which best describes the motion of **object 3**?

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

7d) Between times $t = -5.0$ s and $t = 0.0$ s, which best describes the motion of **object 3**?

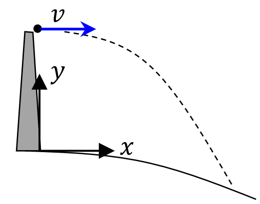
Speeding up the entire time	*Slowing down* the entire time	First *speeds up* then *slows down*	First *slows down* then *speeds up*	Impossible to determine without more info	None of the other answers is correct

7e) What is *displacement* of **object 1** over the entire 10 second time interval?

7f) Estimate *velocity* of **object 3** at time $t = -4.0$ s.

7e	
7f	

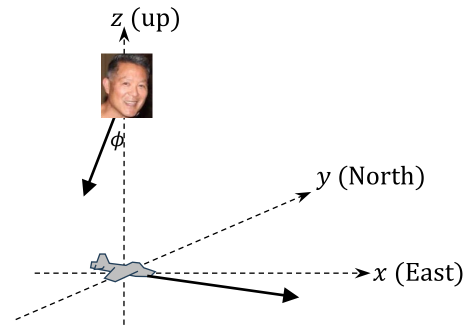
A ball is atop a lookout tower of height h. The ball is kicked horizontally with initial speed v. The hill impacted by the ball can be modeled by the equation $y = -cx^2$ where c is a positive constant. This equation assumes a standard coordinate system with the origin at the base of the tower as shown. Assume the size of the ball is negligible. Assume air resistance is negligible.



*****8) Determine time to impact in terms of given parameters and g.

8	

At time $t = 0$, a floating Len Miyahara Head (LMH) moves in the xz-plane with speed $47.5\,\frac{\mathrm{m}}{\mathrm{s}}$ at angle $\phi = 22.5°$ to the z-axis relative to the earth. At the same instant, the LMH's radar detects a plane $33.3\ \mathrm{m}$ directly below. The LMH's radar indicates the plane flies past the origin at $80.0\,\frac{\mathrm{m}}{\mathrm{s}}$ heading $62.5°$ east of south relative to itself. Figure not to scale.



****9a) Determine *speed* of the plane *relative to earth*.

**9b) Determine *direction* of the plane's motion relative to earth.
Answer with a unit vector in Cartesian form.

9a	
9b	

**10) Angular momentum of a particle is defined as $\vec{L} = \vec{r} \times \vec{p}$.
At some instant we are told that a particle has $\vec{r} = (2.00\ \hat{\imath})\text{m}$
and $\vec{p} = \left(-3.00\hat{\imath} - 4.00\hat{\jmath} - 5.00\hat{k}\right)\text{kg} \cdot \frac{\text{m}}{\text{s}}$.
Determine angular momentum of the particle *in Cartesian form*.

10	

A particle with initial velocity v_0 is constrained to move in one dimension has an acceleration given by

$$a = -kv$$

Here k is an unknown positive constant.
11a) What units are assumed on k?
****11b) Determine velocity as a function of time.

11a	
11b	

Two track stars run a race of distance d. Angelica runs the entire race with constant speed v. Billie gives Angelica a short time delay before starting the race. He accelerates from rest at rate a until reaching a speed 30% greater than Angelica. Billie runs the remainder of the race with constant speed. The two finish the race at the same time.

*****12) Determine the time delay required for Billie to reach the finish line at the same time as Angelica? Answer in terms of $d, a,$ & v.

12	

**Extra credit: Explain what each of the symbols in the table would most likely represent to a physicist or engineer assuming that person was provided no additional information. Most of you have a shot at the first two but the remaining two might be difficult.

To notice: Capitalization and italics convey significant information to scientists and engineers in the real world. Please pay close attention to proper capitalization and italics use going forwards.

mT	(in italics)	
Mt	(in italics)	
mT	(no italics)	
Mt	(no italics)	

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