110 Fall 2022 Test 2A 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	5280 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 = 1.602×10^{-19} J
$1\text{ N} = 1 \frac{\text{kg} \cdot \text{m}}{\text{s}^2}$	1 J = 1 N · m	$1\text{ Pa} = 1 \frac{\text{N}}{\text{m}^2}$	
$x_f = x_i + v_{ix}t + \frac{1}{2}a_x t^2$	$v_{fx}^2 = v_{ix}^2 + 2a_x(\Delta x)$	$v_{fx} = v_{ix} + a_x t$	$r = \sqrt{x^2 + y^2}$
$\vec{A} \cdot \vec{B} = AB\cos\theta_{AB}$	$\lVert\vec{A} \times \vec{B}\rVert = AB\sin\theta_{AB}$	$\sin(A \pm B)$ $= \sin A \cos B \pm \cos A \sin B$	$\cos(A \pm B)$ $= \cos A \cos B \mp \sin A \sin B$
$\vec{v}_{ae} + \vec{v}_{eb} = \vec{v}_{ab}$	$\hat{r} = \cos\theta\,\hat{\imath} + \sin\theta\,\hat{\jmath}$	$\hat{\theta} = -\sin\theta\,\hat{\imath} + \cos\theta\,\hat{\jmath}$	
$a_{tan} = r\alpha$	$a_c = \frac{v^2}{r} = r\omega^2$	$\vec{a} = a_r\hat{r} + a_{tan}\hat{\theta}$	$\vec{a} = a_c(-\hat{r}) + a_{tan}\hat{\theta}$
$\Sigma\vec{F} = m\vec{a}$	$f \le \mu n$		

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}

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

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

Name:_____

Wanda runs a 40.0 m sprint. She runs the first 15.00 m by accelerating (from rest) at constant rate $3.75\,\frac{m}{s^2}$. She finishes the rest of the distance at constant speed.

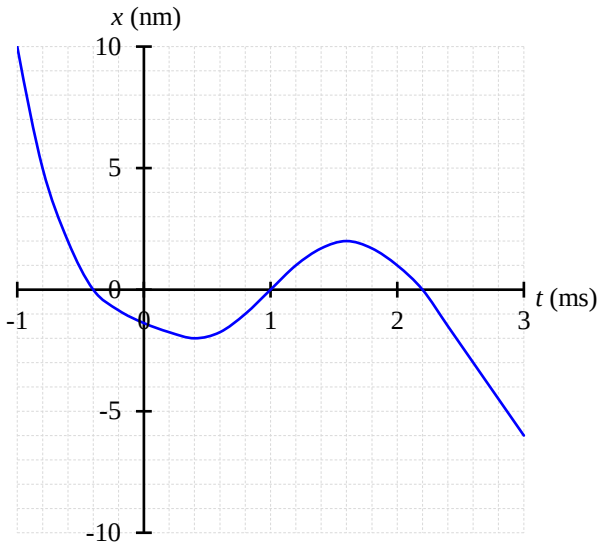
**1a) How long is Wanda accelerating?

**1b) With what speed does Wanda finish the race?

**1c) How long does it take Wanda to run the entire 40.0 m?

1a	
1b	
1c	

A plot of position versus time for an object moving in 1D motion is shown at right. For answers on this page which require a direction, you need not include a unit vector. I assume positive answers imply directed to the right and negative answers imply directed to the left.



2a) At what times (or over what time intervals) is the object at rest? If this doesn't occur during the time interval shown, answer "doesn't occur".

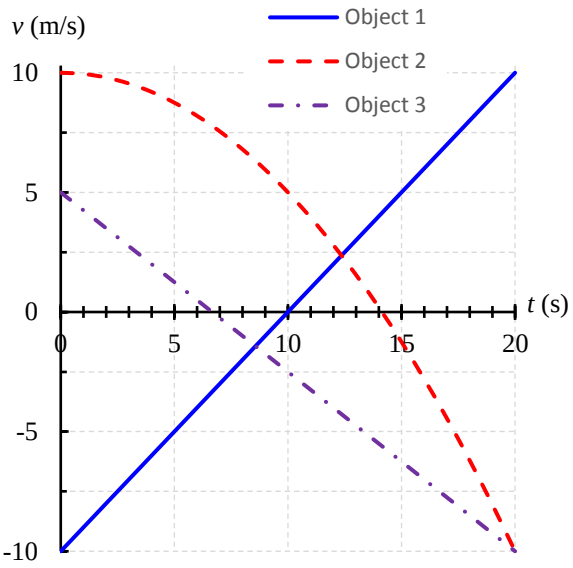
2b) At what times (or over what time intervals) is the object *moving left* and *speeding up*? If this doesn't occur during the time interval shown, answer "doesn't occur".

2c) Estimate total *displacement* over the entire 4.0 ms time interval shown.

2d) Estimate total *distance traveled* over the entire 4.0 ms time interval shown.

**2e) Estimate *velocity* of the object at $t = -0.40$ ms. Show your work for credit.

Velocity versus time plots are shown for three objects in 1D motion.

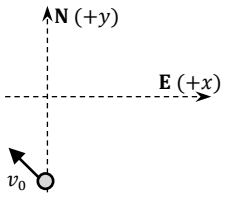


3a) Which object (if any) is initially *moving forwards*? If none are, answer "none". Otherwise, list all objects initially moving forwards.

3b) Which object experiences *negative displacement* over the entire time interval shown? If none are, answer "none". Otherwise, list all objects which experience negative displacement.

3c) Which object has (or objects have) the largest *initial speed*?

A drone, initially distance d due south of the origin travels in 2D motion (figure at right shows the view from above). The drone is initially travelling with speed v_0 directed 45° north of west as shown in the figure. The drone accelerates due east with constant rate a. A short time after the instant shown in the figure, the drone crosses the *vertical* axis.



4a) Which best describes the *horizontal displacement* of the drone at the instant it crosses the *vertical* axis? Circle the best answer.

positive	zero	negative	Impossible to determine without more info

4b) Which best describes the *horizontal velocity component* of the drone at the instant it crosses the *vertical* axis? Circle the best answer.

positive	zero	negative	Impossible to determine without more info

4c) Which best describes the *vertical velocity component* of the drone at the instant it crosses the *vertical* axis? Circle the best answer.

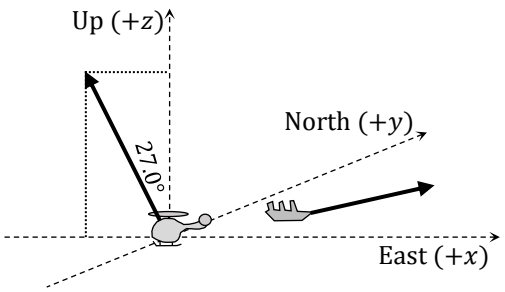
positive	zero	negative	Impossible to determine without more info

4d) Which best describes the relationship between v_0 and the final speed (when crossing the vertical axis)? Circle the best answer.

$v_0 > v_f$	$v_0 = v_f$	$v_0 < v_f$	Impossible to determine without more info

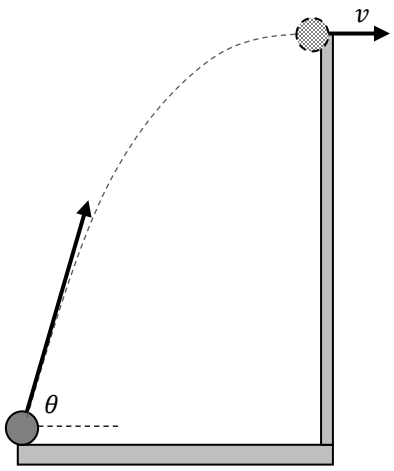
A boat is travelling at $13.00\,\frac{\text{m}}{\text{s}}$ headed 36.5° north of east (in the xy-plane) as measured relative to the earth. A helicopter ascends with speed $9.25\,\frac{\text{m}}{\text{s}}$ in the direction shown (in the xz-plane) as measured relative to the earth.

******5a) & 5b) Determine *speed* and *heading* of the helicopter *relative to the boat*. The heading (or direction) of the helicopter's motion relative to the boat should be expressed as a unit vector (hat vector). First get the velocity vector and then convert that to a unit vector.



speed	
heading	

A ball of negligible size is kicked at launch angle θ. The ball impacts the very top of a post while moving horizontally with impact speed v. The post is located horizontal distance d from the initial location of the ball. Assume air resistance is negligible.



6a) Notice, just before impact, the ball is essentially at max height. Which best describes the *acceleration* of the ball just before impact (at max height)?

Zero	Non-zero	Impossible to determine without more info

6b) Which best describes the *velocity* just before impact (at max height)?

Zero	Non-zero	Impossible to determine without more info

6c) Is the *horizontal* component of velocity larger at impact or at launch? For this question launch implies the instant just after the foot is no longer in contact with the ball. Circle the best answer.

Larger at launch	Larger at impact	Same	Impossible to determine without more info

For the rest of this problem, answers should be algebraic expressions.
6d) Determine time to impact the post.
6e) Determine launch speed in terms of only v & θ.
****6f) Determine the height of the post.
Express your final answer in terms of only given quantities and g.

6d	
6e	
6f	

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