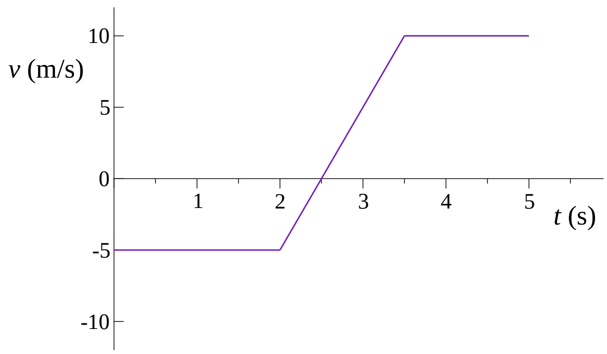
Name=		**Studio Day/Time=**
Eng. Phys. I	**Exam 1 - Chs. 1,2,3,4 - Kinematics**	**Sep. 10, 2021**

Write **neat** & **clear** work. Show **formulas** used, essential steps, results with correct **units** and **significant figures**. Points shown in parenthesis. For TF and MC, choose the *best* answer. Ignore air resistance. Use $g = 9.80\ \mathrm{m/s^2}$.

1. (22) A particle starts at $x_0 = 10.0$ m at time $t = 0$, moving along a straight line (the x-axis) for 5.0 seconds according to the velocity graph shown here.



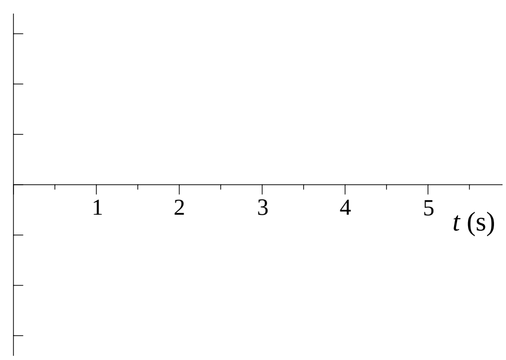
a) (8) Calculate the particle's position x at $t = 5.0$ s.

$x(5.0\ \mathrm{s}) =$ ______________

b) (6) Calculate the particle's average velocity between $t = 0$ and $t = 5.0$ s.

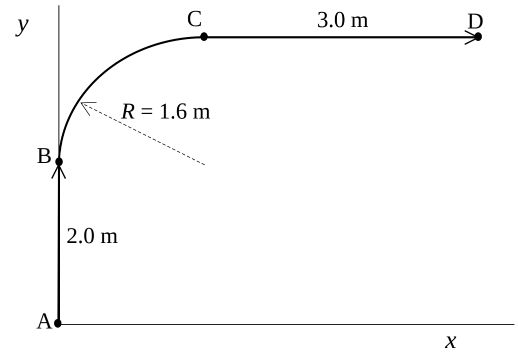
$v_{\mathrm{avg}} =$ ______________

c) (8) Make a sketch here of the instantaneous acceleration between $t = 0$ and $t = 5.0$ s. Be sure to label the vertical axis with correct numbers and units.



2. (26) A bee flies from point **A** through points **B** and **C** to point **D** along the path shown at a constant speed of 8.2 m/s. AB is 2.0 m long, BC is a quarter circle of radius $R = 1.6$ m, and CD is 3.0 m long.

a) (6) Find the components of the net displacement vector experienced by the bee in traveling from **A** to **D**.



$\Delta\vec{\mathbf{r}} =$ ___________ $\hat{\mathbf{i}}$ + ___________ $\hat{\mathbf{j}}$

b) (6) Determine the magnitude and direction (relative to x-axis) of the bee's net displacement vector from **A** to **D**.

$|\Delta\vec{\mathbf{r}}\,| =$ ___________, $\theta =$ ___________

c) (6) How much time elapsed for the bee to travel from **A** to **D**?

$\Delta t =$ ___________

d) (8) Find the components of the bee's *average* acceleration vector while traveling from point **A** to point **D**.

$\vec{\mathbf{a}}_{\text{avg}} =$ ___________ $\hat{\mathbf{i}}$ + ___________ $\hat{\mathbf{j}}$

3. (16) In a baseball game a pitched ball is initially traveling at 98 mph (due south) when the batter hits it and gives it a speed of 128 mph due north. The ball is in contact with the bat for 3.2 ms.

a) (8) Find the average acceleration of the ball, in SI units, while contacting the bat.

$a_{\text{avg}} =$ ______________, direction = ______________

b) (8) Assuming constant acceleration, through what distance was the ball displaced while contacting the bat?

$\Delta x =$ ______________, direction = ______________

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4. (16) A ball is thrown vertically straight up in the air.

a) (8) How fast must its initial speed be so that it lands back on the ground in 10.0 seconds?

$v_0 =$ ______________

b) (8) How high does the ball go?

$h =$ ______________

5. (16) At time $t = 0$ a football is kicked off from the ground. After 1.00 s its velocity is $\vec{\mathbf{v}} = (12.0\hat{\mathbf{i}} + 8.0\hat{\mathbf{j}})$ m/s, where $\hat{\mathbf{i}}$ is along the ground and $\hat{\mathbf{j}}$ is vertical. It later lands on the level ground.

a) (8) What was the velocity of the ball just after it was kicked?

$\vec{\mathbf{v}}_0 =$ __________ $\hat{\mathbf{i}}$ + __________ $\hat{\mathbf{j}}$

b) (8) How far away from the launch point does the ball land?

$x =$ __________

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6. (10) You're driving along a highway at a constant speed and come to a curve in the road whose radius of curvature is 125 m. At what speed in km/h would your centripetal acceleration be equal to $1\ g = 9.80$ m/s^2?

$v =$ __________ km/h.

Total Score = __________/106

Prefixes

z=10^{-21},	a=10^{-18},	f=10^{-15},	p=10^{-12},	n=10^{-9},	$\mu = 10^{-6}$,	m=10^{-3},	c=10^{-2},	k=10^{3},	M=10^{6},	G=10^{9},	T=10^{12},	P=10^{15},	E=10^{18},	Z=10^{21}
zepto,	atto,	femto,	pico,	nano,	micro,	milli,	centi,	kilo,	mega,	giga,	tera,	peta,	exa,	zeta.

Physical Constants

$g = 9.80$ m/s^2 (gravitational acceleration) $G = 6.67 \times 10^{-11}$ N·m^2/kg^2 (gravitational constant)
$M_E = 5.98 \times 10^{24}$ kg (mass of Earth) $R_E = 6380$ km (mean radius of Earth)
$m_e = 9.11 \times 10^{-31}$ kg (electron mass) $m_p = 1.67 \times 10^{-27}$ kg (proton mass)
$c = 299\ 792\ 458$ m/s (speed of light) 1 amu = 1 u = $1.6605402 \times 10^{-27}$ kg (atomic mass unit)

Units & Conversions (all exact)

1 inch = 1 in = 2.54 cm 1 foot = 1 ft = 12 in = 0.3048 m
1 mile = 5280 ft =1760 yards 1 mile = 1609.344 m = 1.609344 km
1 m/s = 3.6 km/hour 88 ft/s = 60 mile/hour
1 acre = (1 mile)^2/640 = 43 560 ft^2 1 hectare = (100 m)^2 = 10^4 m^2

Geometry

Triangles: $A = \frac{1}{2}bh$, Circles; $C = 2\pi r$, $A = \pi r^2$, arc $= s = r\theta$. Spheres: $A = 4\pi r^2$, $V = \frac{4\pi}{3}r^3$

Trigonometry

$\sin\theta = \frac{\text{(opp)}}{\text{(hyp)}}$ $\cos\theta = \frac{\text{(adj)}}{\text{(hyp)}}$ $\tan\theta = \frac{\text{(opp)}}{\text{(adj)}}$
$\text{(opp)}^2 + \text{(adj)}^2 = \text{(hyp)}^2$ $a^2 + b^2 - 2ab\cos\gamma = c^2$ $\frac{\sin\alpha}{a} = \frac{\sin\beta}{b} = \frac{\sin\gamma}{c}$

Chapter 1 - Measurements

Percent error: If a measurement = value ± error, the percent error $= \frac{\text{error}}{\text{value}} \times 100$ %

Chapter 2 - Vectors - Magnitude & Direction

2D Vectors: $\vec{\mathbf{a}} = a_x\hat{\mathbf{i}} + a_y\hat{\mathbf{j}}$ magnitude = $a = \sqrt{a_x^2 + a_y^2}$ direction → $\tan\theta = a_y/a_x$
Components: $a_x = a\cos\theta$ $a_y = a\sin\theta$ θ=angle to $+x$-axis.
Addition: $\vec{\mathbf{a}} + \vec{\mathbf{b}}$, head to tail. Subtraction: $\vec{\mathbf{a}} - \vec{\mathbf{b}}$ is $\vec{\mathbf{a}} + (-\vec{\mathbf{b}})$ $-\vec{\mathbf{b}}$ is $\vec{\mathbf{b}}$ reversed.

Scalar product: $\vec{\mathbf{a}} \cdot \vec{\mathbf{b}} = ab\cos\phi$ $\vec{\mathbf{a}} \cdot \vec{\mathbf{b}} = a_xb_x + a_yb_y + a_zb_z$ $\hat{\mathbf{i}} \cdot \hat{\mathbf{i}} = 1$, $\hat{\mathbf{i}} \cdot \hat{\mathbf{j}} = 0$, etc.
Cross product: $|\vec{\mathbf{a}} \times \vec{\mathbf{b}}| = ab\sin\phi$ $\hat{\mathbf{i}} \times \hat{\mathbf{j}} = \hat{\mathbf{k}}$, etc. $\hat{\mathbf{i}} \times \hat{\mathbf{i}} = \hat{\mathbf{j}} \times \hat{\mathbf{j}} = \hat{\mathbf{k}} \times \hat{\mathbf{k}} = 0$

Chapter 3 - 1D Kinematics - Straight-line motion

Velocity: $v_{\text{avg}} = \frac{\Delta x}{\Delta t}$ $\Delta x = x - x_0$ $v(t) = \frac{dx}{dt}$= slope of $x(t)$
Acceleration: $a_{\text{avg}} = \frac{\Delta v}{\Delta t}$ $\Delta v = v - v_0$ $a(t) = \frac{dv}{dt}$= slope of $v(t)$

Constant acceleration: $v = v_0 + at$ $v_{\text{avg}} = \frac{1}{2}(v_0 + v)$
$x = x_0 + v_0t + \frac{1}{2}at^2$ $x = x_0 + v_{\text{avg}}t$ $v^2 = v_0^2 + 2a\Delta x$

Free fall ($+y$-axis is up): $y = y_0 + v_{0y}t - \frac{1}{2}gt^2$ $v_y = v_{0y} - gt$ $v_y^2 = v_{0y}^2 - 2g\Delta y$

Chapter 4 - 2D and 3D Motion - Vector displacement, velocity, acceleration

Position: $\vec{\mathbf{r}} = x\hat{\mathbf{i}} + y\hat{\mathbf{j}}$ $\vec{\mathbf{r}} = x\hat{\mathbf{i}} + y\hat{\mathbf{j}} + z\hat{\mathbf{k}}$
Velocity: $\vec{\mathbf{v}}_{\text{avg}} = \frac{\Delta\vec{\mathbf{r}}}{\Delta t}$ $\vec{\mathbf{v}} = \frac{d\vec{\mathbf{r}}}{dt}$ $\Delta\vec{\mathbf{r}} = \vec{\mathbf{r}} - \vec{\mathbf{r}}_0$
Acceleration: $\vec{\mathbf{a}}_{\text{avg}} = \frac{\Delta\vec{\mathbf{v}}}{\Delta t}$ $\vec{\mathbf{a}} = \frac{d\vec{\mathbf{v}}}{dt}$ $\Delta\vec{\mathbf{v}} = \vec{\mathbf{v}} - \vec{\mathbf{v}}_0$

Projectiles: $a_x = 0$ $v_x = v_{x0}$ $x = x_0 + v_{x0}t$
($+y$-axis is up) $a_y = -g$ $v_y = v_{y0} - gt$ $y = y_0 + v_{y0}t - \frac{1}{2}gt^2$

Relative Motion: $\vec{\mathbf{v}}_{\text{BS}} = \vec{\mathbf{v}}_{\text{BW}} + \vec{\mathbf{v}}_{\text{WS}}$ B=Boat, S=Shore, W=Water. BS is "boat relative to shore", etc.
Circular motion: $a_c = v^2/r = \omega^2 r$ $v = 2\pi r/T = \omega r$ $\omega = 2\pi/T$