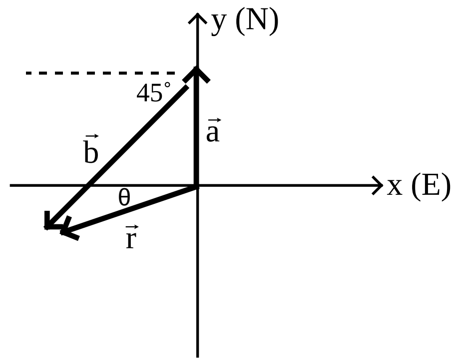
Name:____

Solve the following problems in the space provided. Use the back of the page if needed. Each problem is worth 20 points. You must show your work in a logical fashion starting with the correctly applied physical principles which are on the last page. Your score will be maximized if your work is easy to follow because partial credit will be awarded.

1. A hiker walks 2.50km northward then 5.00km southwest. Find (a)the total distance traveled by the hiker and (b)the total displacement of the hiker. (c)Sketch the three displacements on the axes at the right (+y = north and +x = east).



(a)Distance is not a vector, so distances just add,
$d = a + b = 2.50 + 5.00$ $\boxed{d = 7.50\text{km}}$.

(b) $\vec{a} = 2.50\hat{j}$ and
$\vec{b} = -5\cos 45^\circ \hat{i} - 5\sin 45^\circ \hat{j} = -3.54\hat{i} - 3.54\hat{j}$.

$$\vec{r} = \vec{a} + \vec{b} = (2.50\hat{j}) + (-3.54\hat{i} - 3.54\hat{j}) = (-3.54)\hat{i} + (2.50 - 3.54)\hat{j} = (-3.54)\hat{i} + (-1.04)\hat{j}$$

Using the Pythagorean Theorem,
$$r = \sqrt{r_x^2 + r_y^2} = \sqrt{(-3.54)^2 + (-1.04)^2} \quad \boxed{r = 3.69\text{km}}.$$
and the definition of tangent
$$\tan\theta \equiv \frac{r_y}{r_x} \quad \theta = \arctan\frac{r_y}{r_x} = \arctan\frac{-1.04}{-3.54} \quad \boxed{\theta = 16.4^\circ \text{ south of west}}.$$

(c)see sketch

2. A ball is thrown upward and its height (y) as a function of time (t) is given by the equation, $y = 2.00 + 10.0t - 4.90t^2$ where y is in meters when t is in seconds. Find (a)the position of the ball at t = 2.00s, (b)the velocity of the ball at t = 2.00s and (c)the acceleration of the ball at t = 2.00s. (d)Find the maximum height of the ball.

(a)At t = 2.00s, $y = 2.00 + 10.0t - 4.90t^2 = 2.00 + 10.0(2) - 4.90(2)^2$ $\boxed{y = 2.40\text{m}}$.

(b)Using the definition of speed, $\vec{v} \equiv \frac{d\vec{r}}{dt}$ $v = \frac{dy}{dt} = \frac{d}{dt}\left(2 + 10t - 4.9t^2\right) = 10.0 - 9.80t$.

At t = 2.00s, $v = 10.0 - 9.80t = 10.0 - 9.80(2)$ $\boxed{v = -9.60\text{m/s}}$.

The minus sign means $\boxed{\text{downward}}$.

(c)Using the definition of acceleration, $\vec{a} \equiv \frac{d\vec{v}}{dt}$ $a = \frac{dv}{dt} = \frac{d}{dt}\left(10 - 9.8t\right) = -9.80$.

Since the acceleration is constant, at t = 2.00s, $\boxed{a = -9.80\text{m/s}^2}$.

The minus sign means $\boxed{\text{downward}}$.

(d)The maximum height will occur when the speed is zero so,

$v = 10.0 - 9.80t = 0$ $t = \frac{10.0}{9.80} = 1.02\text{s}$.

At this time the position is,

$y = 2.00 + 10.0t - 4.90t^2 = 2.00 + 10.0(1.02) - 4.90(1.02)^2$ $\boxed{y = 7.10\text{m}}$.

3. The launch tower for the space shuttle is approximately 100m tall. It takes the shuttle about 5.00s to clear this tower. (a)Estimate the acceleration of the shuttle and state any simplifying assumptions you use. (b)Find the velocity of the shuttle as it clears the tower.

(a)$\boxed{\text{Assuming that the acceleration is constant}}$, the kinematic equations can be used.

$y_0 = 0$

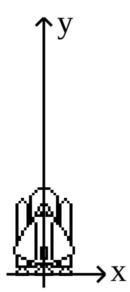
$y = 100\text{m}$

$v_o = 0$

$v = ?$

$a = ?$

$t = 5.00\text{s}$



(a)Using the kinematic equation without the final speed,

$$y = y_o + v_o t + \tfrac{1}{2}at^2 \qquad y = \tfrac{1}{2}at^2$$

and solving for the acceleration,

$$a = \frac{2y}{t^2} = \frac{2(100)}{5^2} \qquad \boxed{a = 8.00\text{m/s}^2}.$$

(b)Using the kinematic equation without the acceleration,

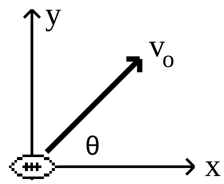
$$y - y_o = \tfrac{1}{2}(v + v_o)t \qquad y = \tfrac{1}{2}vt$$

and solving for the final speed,

$$v = \frac{2y}{t} = \frac{2(100)}{5} \qquad \boxed{v = 40.0\text{m/s}}.$$

4. A punter wants to kick a football so that it spends 4.00s in the air and travels 40.0m down the field. Find the horizontal and vertical components of initial velocity vector of the ball as it leaves the punter's foot.

$x_0 = 0$	$y_0 = 0$
$x = 40.0\text{m}$	$y = 0$
$v_{ox} = ?$	$v_{oy} = ?$
$v_x = ?$	$v_y = ?$
$a_x = 0$	$a_y = -9.80\text{m/s}^2$
$t = 4.00\text{s}$	



Using the kinematic equation without the final velocity,

$$x = x_o + v_{ox}t + \tfrac{1}{2}a_x t^2 \qquad x = v_{ox}t \qquad v_{ox} = \frac{x}{t} = \frac{40}{4} \qquad \boxed{v_{ox} = 10.0\text{m/s}}.$$

Using the kinematic equation without the final velocity,

$$y = y_o + v_{oy}t + \tfrac{1}{2}a_y t^2 \qquad 0 = v_{oy}t + \tfrac{1}{2}a_y t^2 \qquad v_{oy} = -\tfrac{1}{2}a_y t = \tfrac{1}{2}(9.8)(4) \qquad \boxed{v_{oy} = 19.6\text{m/s}}.$$

5. The moon orbits Earth every 27.4days. Find (a)the speed of the moon in its orbit and (b)the acceleration of the moon. (c)A rock dropped from your hand accelerates toward the center of Earth due to gravity. Does the moon accelerate due to gravity? If so, in what direction? The effect of gravity on the rock causes it to fall toward Earth. Why doesn't the moon fall?

(a)Using the definition of speed, $v \equiv \frac{\Delta x}{\Delta t} \qquad v = \frac{2\pi r}{T} = \frac{2\pi(3.82\text{x}10^8)}{(27.4)(24)(3600)} \qquad \boxed{v = 1010\text{m/s}}$.

(b)The centripetal acceleration is $a_c = \frac{v^2}{r} = \frac{(1010)^2}{3.84\text{x}10^8} \qquad \boxed{a_c = 0.00266\text{m/s}^2}$.

(c)The moon also accelerates due to gravity. The acceleration is also toward the center of Earth. This is consistent with the Rule of Falling Bodies. The definition of acceleration is the rate of change of the velocity vector. The gravitational acceleration causes a change in the moon's velocity vector. The moon has precisely the correct velocity perpendicular to the gravitational acceleration so that the moon's velocity vector only changes direction and it remains perpendicular to the acceleration. Since the velocity has no component toward Earth, the moon stays same distance away.