Name: _____
Hour: ____ Date: _____

Physics: *Vectors and 2-D Motion HW*

Set 1: Vectors, Scalars, and Graphical Addition of Vectors

1. Which of the following quantities are scalars, and which are vectors?

A. the acceleration of a racecar
B. the number of members of the pit crew
C. the time that elapses during the race
D. the total displacement of the racecar
E. the mass of fuel required for the race
F. the maximum velocity of the racecar

2. A hiker walks 85.0 m on level ground, then travels 45.0 m up a 30.0^{o} hill. Find his displacement. Use the graphical method of vector addition.

3. A plane's controls are set so that, in the absence of wind, the plane would fly at 250. km/h north. If the wind blows at 75.0 km/h southeast, find the plane's resultant velocity. Use the graphical method of vector addition.

4. With reference to Q3, find the plane's resultant velocity if the controls are set to 125 km/h north and the wind continues to blow at 75.0 km/h southeast. Again, use the graphical method of vector addition.

5. In the Indianapolis 500, Indy cars race 200 times around an oval-shaped, 2.50-mile track, for a total distance of 500 miles. What is the displacement of a car during one lap around the track?

ANSWERS: 2. ~126 m @ 10.0^{o} above horiz. 3. ~204 km/h @ 15.0^{o} E of N 4. ~89.5 km/h @ 36.5^{o} E of N

Set 2: Algebraic Addition of Perpendicular Vectors

6. A taxi driver travels 12 km east, and then he turns around and travels 6 km west. Finally, he turns again and travels 15 km east.

   A. What distance has the taxi traveled?

   B. What is the taxi's total displacement?

7. A member of a marching band marches 18.0 m north and then 7.0 m east. What straight-line displacement could the student have taken?

8. A butterfly, 3.8 m above the ground, flies 1.2 m horizontally before dropping directly downward 1.4 m. What is the butterfly's displacement, relative to its starting point?

9. A lion walks E_1 km east, then N km north, then E_2 km east, and finally S km south. In terms of E_1, N, E_2, and S, find the magnitude and direction of the lion's resultant displacement vector, $\mathbf{d_r}$. For simplicity, assume that the magnitude of the lion's northward vector is larger than its southward vector.

Set 3: Vector Resolution

10. At a particular instant of time, an arrow arcs upward at a speed of v m/s and at an angle of θ above the horizontal. In terms of v and θ, find the horizontal (v_x) and vertical (v_y) components of the arrow's velocity at that instant of time.

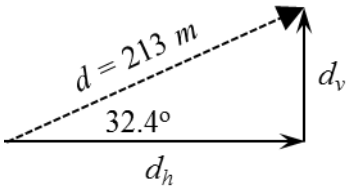
ANSWERS:

6A. 33 km
6B. 21 km E
7. 19 m @ 21^o E of N
8. 1.8 m @ 49^o below horiz.

11. For each vector described below, do the following:

- Sketch each given vector.
- Label the magnitude of the given vector and drawn in its angle. For N/S/E/W vectors, draw all vectors assuming that north is directed toward the top of the page.
- Label the components in a meaningful way (e.g. "F_w" for the **west** component of a given **force** vector).
- Determine the magnitude and direction of each component. Show your work. Round to the proper number of sig. figs. and put correct units and directions on each component.

EXAMPLE: A hiker walks 213 m up a hill that is inclined at 32.4°.



$d_h = 213 \cos 32.4 =$ $\boxed{180.\ m \rightarrow}$

$d_v = 213 \sin 32.4 =$ $\boxed{114\ m \uparrow}$

A. A drag racer accelerates at 16 m/s^2 along a racetrack oriented 17° north of west.

B. A dock worker pulls on a rope attached to a boat with a force of 382 N at 59.3° east of south.

C. A worker pushes a wheelbarrow at a rate of 1.34 m/s up a ramp inclined at 27.2°.

D. At some instant, a baseball falls at 19.8 m/s at 12.2° to the left of vertical.

E. A cyclist pedals 325 m along a road oriented 41.5^{o} north of east.

F. A jet that has just taken off is ascending 35.1 m/s at 18.7^{o} above the horizontal.

G. A vendor pushes his cart with a force of 188 N down a street oriented 73.4^{o} west of south.

H. A fighter jet descends at a speed of 58 m/s at 52^{o} below the horizontal.

I. A snowplow pushes snow along the road with a force of 980 N at 21^{o} east of north.

J. A go-cart accelerates 2.31 m/s^2 in a direction 38.7^{o} south of east.

K. The wind applies a 707 N force on a sailboat, pushing it 61.2^{o} west of north.

L. A firework travels 350 m in a direction 8.6^{o} to the right of vertical before exploding.

Set 4: Algebraic Addition of Non-Perpendicular Vectors

12. A hockey player skates 13.0 m straight before turning to the right at an angle of 35.0^{o} from his original direction and skating an additional 15.0 m. What is the player's total displacement?

13. A hiker walks 2.5 km up a 35^{o} hill. Then the hill's slope changes to 22^{o} and the hiker goes another 5.2 km. What is the magnitude and direction of the hiker's total displacement?

14. A treasure-seeker walks on a beach with a metal detector. First, he walks 8.0 m north. Then, he turns 55^{o} north of east and walks 3.5 m. Finally, he turns east and walks 5.0 m. What is his total displacement?

15. A tank crew practicing maneuvers drives their tank through two displacements. The first is 75.0 km 30.0^{o} west of north, and the second is 155 km 60.0^{o} east of north. What is the total displacement of the tank?

ANSWERS:

12. 26.7 m @ 18.8^{o} to rt. of orig. dir.
13. 7.7 km @ 26^{o} above horiz.
14. 13 m @ 33^{o} E of N
15. 172 km @ 55.8^{o} N of E

16. A hiker is climbing a hill. During the first portion of the climb, the hiker walks a distance D_1 along the hill at an angle of Θ above the horizontal. Then, the slope of the hill changes to the angle Φ above the horizontal and the hiker walks an additional distance D_2. In terms of D_1, Θ, D_2, and Φ, find the magnitude and direction of the hiker's resultant displacement vector, $\mathbf{d}_r$.

Set 5: Projectiles Launched Horizontally

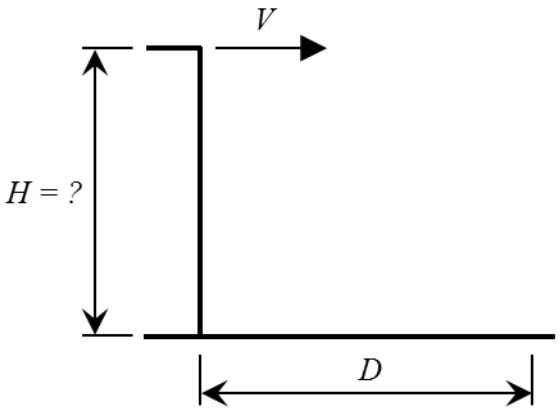
17. A stone is thrown horizontally off a 19 m-high cliff and lands 8.5 m away from the base of the cliff. How fast was the stone thrown?

18. A tennis ball rolls off a 1.3 m-high workbench and lands 1.6 m from the edge of the bench. When the ball rolled off the table, what was its speed?

19. An owl flying 8.8 m/s horizontally drops a field mouse from a height of 4.3 m above the ground. How far horizontally does the mouse travel before it lands?

ANSWERS: 17. 4.3 m/s 18. 3.1 m/s 19. 8.2 m

20. A rifle bullet fired horizontally at a speed V from the top of a cliff lands in the desert sand a distance D from the base of the cliff. In terms of V, D, and the acceleration due to gravity g, find the height of the cliff H.



Set 6: Coordinates of Horizontally Launched Projectiles

21. A softball is thrown horizontally with a speed of 15.0 m/s off a cliff of height 40.0 m. Find the location and speed of the ball 1.28 s after the ball is released.

22. A projectile is launched horizontally from the top of a tall building. At 3.18 s after launch, it is 35.8 m above the ground and is 72.5 m away (horizontally) from the building.

A. What is the height of the building?

B. What was the launching speed of the projectile?

ANSWERS: 20. $H = (gD^2)/(2V^2)$ 21. 19.2 m →, 8.04 m below launch point; 19.6 m/s 22A. 85.4 m 22B. 22.8 m/s

Set 7: Projectiles Launched at an Angle

23. A football is punted from, say, the origin. It is in the air for 4.40 s and obtains a range of 48.0 m. Find:

A. the time it takes for the ball to get to the top of its trajectory

B. the velocity of the football at the top of its trajectory

C. the maximum altitude obtained by the ball

D. the football's initial velocity (i.e., its initial speed and the angle above horizontal)

E. the football's x- and y-coordinates 1.80 s after it was kicked

F. the football's velocity 1.80 s after it was kicked

ANSWERS:

23A. 2.20 s	23C. 23.7 m	23E. (19.6 m, 23.0 m)
23B. 10.9 m/s →	23D. 24.2 m/s @ 63.2^{o} above horiz.	23F. 11.6 m/s @ 19.9^{o} above horiz.

24A. A projectile is launched from the origin at 68.5 m/s at 53.3^{o} above the horizontal. Find its x- AND y-coordinates 2.65 s after launch, assuming the projectile is launched on Earth.

24B. Find the velocity of the projectile from Q24A at 2.65 s.

25. Solve Q24A AND Q24B again, this time assuming that the projectile is on Mars, where g = –3.71 m/s^{2}.

26. A projectile is fired from the origin at 27.3 m/s at 41.0^{o} above the horizontal. Determine the x- and y-coordinates AND the velocity of the projectile at 2.82 s.

ANSWERS:

24A. (108 m, 111 m)
24B. 50.1 m/s @ 35.2^{o} above horiz.

25. (108 m, 133 m)
60.9 m/s @ 47.8^{o} above horiz.

26. (58.1 m, 11.5 m);
22.8 m/s @ 25.4^{o} below horiz.