1. An inclined railway travels at a speed of 1.10 m/s while climbing at an angle of 35.0°. The railway delivers riders to the top of a mountain – a change in elevation of 125 m. (a) Determine the rate at which the train's elevation increases. (b) Determine the time for it to reach the top.

2. An airplane flying over Kansas with speed 410 km/h descends from an elevation of 4500 m to 2500 m in 145 seconds. (a) Determine the descent rate of the airplane. (b) Determine how far the plane has traveled over the ground during its descent.

3. A policeman's radar is pointed in a northward direction and measures a car passing by that is traveling 10.0° east of north. The radar gun indicates 75 mph. What is the actual speed of the car? Hint: the radar gun only measures a component of the car's velocity.

4. A radar gun initially shows value v_{r1} for an object passing by with constant velocity. As the object moves the gun shows a different value v_{r2} when it is pointed at angle ϕ relative to the first reading. Determine the object's true speed and direction of motion relative to the initial aim of the radar gun.

5. An airplane has airspeed 375 km/h and heading 30.0° while encountering a wind of 45.0 km/h south. Find the groundspeed and course.

6. A boy that can swim at 1.5 m/s heads directly across a river that flows at 0.80 m/s and is 20.0 m wide. (a) What is the speed of the boy relative to earth? (b) How much time does it take to cross? (c) How far downstream is he relative to his starting point on the other side? (d) Can he cross in less time if he is doesn't care where he lands? Explain.

7. In order to maintain a westward course and speed over ground of 20.0 km/h, what must be the speed through water and heading of a ship that encounters a current of 4.0 km/h southward?

8. Suppose the wind is 55.0 km/h, 30.0°. (a) In order to maintain a course of 90.0° in such a wind, what heading is required of an airplane with airspeed 295 km/h? (b) If the destination is 1750 km, 90.0° how much time is "saved" due to the wind?

9. A wind can reduce or increase the time required for a flight. Let θ be the angle between the wind and the desired course direction. Determine the value of θ at which the wind w has no effect on flight time for an aircraft with airspeed u.

10. A pilot flies from City A to City B. City B is a distance d due east from City A. Suppose the plane has airspeed v_{PA} and encounters a northerly wind with speed v_{AE}. (a) Solve for the flight time, t, and the required heading of the airplane, θ, in terms of other relevant variables. (b) Repeat this problem but now allow for a wind with an arbitrary direction, φ.

11. A truck is traveling east at 50.0 mph. At an intersection 20.0 miles ahead, a car is moving north at 30.0 mph. How long after this moment will the two vehicles be closest to each other? How far apart will they be at that point?

12. A physics nerd is driving a car with a broken speedometer through falling snow. Relative to the earth, the snow falls straight down with speed 4.0 m/s. The nerd notes that the snow appears to be falling at an angle of 60.0° with respect to the vertical while he is driving. The nerd uses these facts to determine his speed – what is the result?

13. A ball is thrown with initial velocity 10.0 m/s, 0° out a window that is 15.0 m above the ground. (a) Determine the range of the ball. (b) Find the impact velocity.

14. A projectile launched vertically reaches a height h before falling back down. The same object is then launched horizontally by the same mechanism from a height of y above the floor. Determine the range x it travels across the floor in terms of h, y, and any appropriate physical constants.

15. A projectile is launched over level ground with initial speed v_o and angle of elevation θ. Ignoring air resistance, show that the projectile moves in a parabolic path. Derive equations for range and for maximum height in terms of v_o and θ and show that maximum range is achieved at $\theta = 45°$.

16. A kid shoots a basketball at an angle of 50.0° above the horizontal and makes a basket. The hoop that the ball goes through is located 4.0 m horizontally and 1.5 m vertically away from the point where the ball was released. Determine the velocity of the ball as it goes through the hoop.

17. Determine an equation for making a free throw! The rim of the basket is 10 feet high and the foul line is 13 feet 9 inches from the centerline of the rim. Assume that the ball is launched from a height of 6 feet. Find the equation that defines all successful free throws in terms of v_o and θ. (Note: $g = 32.2$ ft/s^2)

18. A certain car has distance given by: $d = 3.8t^2 - 0.067t^3$ as it accelerates to its top speed. (a) Determine the speed and rate of acceleration at t = 10.0 s. (b) Find the speed when the acceleration is equal to zero. (c) Determine the maximum acceleration rate.

19. An object moves along the x-axis according to the function $x(t) = 5 - 2t + 3t^2 - 0.5t^3$, where t is time measured in seconds and x is position measured in meters. For the interval of time $t = 0$ to $t = 4.0$ s determine: (a) average acceleration, (b) maximum rate of acceleration, (c) average velocity, (d) maximum speed, and (e) maximum distance from the origin.

20. For each of the following expressions determine the antiderivative (indefinite integral) with respect to time:

(a) $v(t) = 6t^3 - 5t$
(b) $a(t) = 3t^2 - 4t + 7$
(c) $a(t) = 10 + t^{-2}$
(d) $v(t) = 2t^5 - t^4/3$
(e) $v(t) = 12t^{0.5} + 15$

21. Beginning at a position 1.0 m to the right of the origin, an object moves along the x-axis with velocity in m/s given by $v(t) = 0.20t^4 - t^2$, where t is in seconds. (a) Determine its position, velocity, and acceleration at $t = 2.0$ s. (b) For $t > 0$, determine the greatest leftward position, speed, and acceleration.

22. A certain car is reported by a magazine to complete a "standing quarter mile" in 14.5 seconds with an ending speed of 95 mph or 139 ft/s. (a) Determine the average acceleration. (b) Assuming the acceleration is constant calculate the distance the car should travel in 14.5 seconds. How does this compare with one quarter mile (1320 ft)? Explain the discrepancy!

23. The magazine reported data for time and speed of the same car as shown in the table below. Assuming that speed is proportional to the square root of the time, find an equation for $v(t)$ to model this data. (a) Use this model to determine the functions $x(t)$ and $a(t)$. (b) Calculate $x(14.5\text{ s})$ and compare to one quarter mile. (c) The magazine reported the top speed of this car as 151 mph or 221 ft/s. Determine the acceleration of the car as it reaches 151 mph according to your functions. What does this result tell us about the functions?

Time (s)	Speed (mph)	Converted Speed (ft/s)
0	0	0

1.9	30	44.0
3.0	40	58.7
4.3	50	73.3
5.9	60	88.0
7.7	70	102.7
10.2	80	117.3
13.0	90	132.0
16.2	100	146.7
20.2	110	161.3
26.9	120	176.0
36.2	130	190.7

24. Try a different approach to the car in the previous example: Assume that the acceleration decreases linearly such that $a(t) = mt + b$. (a) Determine values for m and b based on the known quarter mile (1320 ft) time of 14.5 s and final speed of 139 ft/s. (b) What is the initial acceleration? (c) Use this new model to determine the top speed of the car.

25. The position of a particle is given by $x(t) = 4.0\ t^2$ and $y(t) = 0.5\ t^3$ m. (a) What are the velocity and acceleration of the particle at $t = 2.0$ s? (b) Determine the equation of the path that the particle travels along.

26. At the same time a truck is accelerating forward 3.0 m/s^2 from rest, a pebble at the front end of the truck's bed is observed to accelerate backward 1.4 m across the bed in 1.5 s before falling out. The bed of the truck is 0.80 m above the road. (a) Relative to the *truck*, what is the velocity of the pebble as it falls off? (b) Relative to the *earth*, what is the velocity as it falls off? (c) Relative to *earth*, what is the total horizontal distance traveled by the pebble before it hits the ground? (d) Relative to the *truck*, what is the total horizontal distance traveled before hitting? (e) Sketch the path of the pebble's motion as seen from each frame of reference.

27. A truck with initial velocity 5.0 m/s north accelerates uniformly at 1.0 m/s^2 north. At the same instant a mouse in the bed of the truck accelerates from rest uniformly at 3.0 m/s^2 east, relative to the surface of the truck's bed. (a) Write the parametric equations $x(t)$ and $y(t)$ that describe the mouse's motion. (b) Relative to the earth, determine the velocity and acceleration of the mouse when it has moved 1.2 m across the bed of the truck from its original position. (b) Determine an equation that would describe the path of the mouse's motion relative to the earth.