Kinematics.

1. (a) What is the acceleration of a United States Air Force F-16 jet fighter initially at rest in order to reach a speed of 108 m/s in a distance of 550 m (assuming the acceleration is constant)? (b) How much time would pass for the jet to reach the minimum take-off speed of 78 m/s?

2. A penny dropped off the Mackinac Bridge takes approximately 3.51 s to hit the water. (a) How high is the Mackinac Bridge? (b) How fast is the penny going when it hits the water?

3. Your Detroit-to-Burkina Faso "vacation" (all the while carrying $4 million in unmarked small denomination bills) requires a $2\frac{1}{2}$-h flight from Detroit to Atlanta, a 4-hr layover, then an 8-h nonstop flight from Atlanta to Madrid before catching a commuter to Casablanca. After yet another $2\frac{1}{2}$-h flight – following a sleepless 8 h layover in the Madrid airport trying to decipher menus in Spanish; a language you decided not to study in high school because you never thought you would need it – you manage to hook up with a somewhat disreputable bush pilot who agrees to fly you to the Burkina Faso capital of Ouagadougou. Seven hours later, you arrive at the airport and are immediately arrested for entering the country illegally. If the distance from Detroit to Ouagadougou is 8388 km, what was your average speed?

4. A bullet is shot vertically upward and reaches a maximum height of 12 km. What was its initial velocity?

5. Given vectors $\boldsymbol{R}$ = (22 m/s, 46º) and $\boldsymbol{S}$ = (18 m/s, 207º), (a) what is the magnitude of the resultant vector in the *x*-direction? (b) What is the magnitude of the resultant vector in the *y*-direction? (c) What is the resultant vector?

6. Why was Galileo Galilei able to assume that objects act like point particles?

7. A model rocket lifts off with a constant acceleration to a height of 3.2 m, at which point its speed is 32 m/s. (a) How much time does it take for the rocket to reach this height? (b) What was the rocket's acceleration? (c) What is the height and speed of the rocket 0.15 s after launch?

8. If you are caught out in a rainstorm, should you stop, walk, or run? Explain your reasoning. Assume the raindrops are falling vertically.

9. A hot air balloon has just lifted off and is rising at a constant rate of 2.0 m/s. Suddenly, one of the passengers realizes she has left her camera on the ground. A friend picks it up and tosses it straight upward with an initial speed of 10. m/s. If the passenger is 2.5 m above her friend when the camera is tossed, how high is she when the camera reaches her?

10. An astronaut on the Moon drops a rock hammer straight downward from a height of 0.95 m. If the acceleration of gravity on the Moon is $\frac{1}{6}^{\text{th}}$ that of Earth, what is the speed of the hammer when it lands?

11. As the Amtrak Wolverine Express accelerates from the Kalamazoo Depot on the way to Chicago, it reaches a speed of 5.3 m/s in 5.0 s. If the train's acceleration remains constant, (a) what is its speed after an additional $7\frac{1}{2}$ s has elapsed? (b) How far will it have traveled in that time?

12. Does a speedometer measure speed or velocity?

13. You are driving down Westnedge Avenue toward the Center when you see a traffic light turn red. You apply the brakes until you come to a stop. If your initial speed was 35 mi/h and you come to a complete stop in 3.5 s, how far did you travel before stopping?

14. An eagle perched on a tree limb 7.5 m above the water spots a swimming fish swimming. The eagle flies off and descends toward the water at a velocity of $\boldsymbol{v}$ = (3.1 m/s, –20º). How far has the eagle traveled horizontally when it reaches the water?

15. On October 9, 1992, a 27-lb meteorite struck a car in Peekskill, NY, leaving a dent 22 cm deep in the trunk. If the meteorite struck the car with a speed of 535 m/s, what was the magnitude of its deceleration, assuming it to be constant?

16. Given projectile motion in both the *x*- and *y*-directions, show that $y = v_o(\sin\theta)t - \frac{1}{2}gt^2$ and $x = v_o(\cos\theta)t$ together yield

$$\mathrm{R} = \frac{v_o^2(\sin 2\theta)}{g}$$

which is known as the range equation.

17. In the movie THE LORD OF THE RINGS: THE RETURN OF THE KING, Minas Tirith is attacked by the Orcs of Mordor. One of the devices used to defend the White City is a siege engine known as a *trebuchet*. If the trebuchet launches a 66-kg stone with an initial velocity of 88 m/s at an angle of 44º, (a) how far does the stone travel? (b) How long is it in the air? Assume the initial height and the final height of the stone is the same.

18. A baseball is thrown horizontally from the top of a 25-m high hill with an initial velocity of 25 m/s. (a) What was its final velocity? (b) How far from the base of the hill did it land?

19. In the Aristotelian view, there was "violent" motion and "natural" motion. (a) Describe the differences between them. (b) How did Galileo Galilei eliminate the two types of motion?

20. Wile E. Coyote is hot on the trail of the Roadrunner. This time, he plans on shooting himself out of an Acme™ All-Purpose Cannon across a deep canyon to where the Roadrunner awaits. He decides to launch himself at angle of 60.º above the horizontal so that he can spend more time in the air waving to the expected throng of adoring fans (after all, he *is* a supergenius). With what velocity must he be launched at in order to cross the 510-m wide canyon?

21. (a) What is free fall? (b) Why does free fall *not* mean that there is no gravity?

22. Marksmen know that, when sighting in a rifle at a specific range, the bullet will hit the target above the aiming point if the target is closer to the muzzle of the rifle and will strike below the aiming point if farther out. Why is that?

23. In a game between the Detroit Tigers and the hated Minnesota Twins, a ground ball is hit to the third baseman. If the distance from the fielder to the first baseman is 124 ft, (a) what must the velocity of the ball be to reach the bag without hitting the ground? (b) If the ball is thrown at an initial angle of 15º above the horizontal, what must the velocity be now?

24. Show that for an object launched at an angle of 45º, the maximum height is $\frac{1}{4}$ that of the range.