Phyz Question and Problem Set

2.01 ADVANCED KINEMATICS

9/1/10 PM

Section I: Do You Know? Do You Know? Do You Know?

BASIC CONCEPT QUESTIONS

INSTRUCTIONS: The following questions require written responses. Answers may include diagrams and/or references to equations. Respond in complete sentences and include a statement of the question in your response. Leave at least one blank line between your answers.

Projectile Motion *(Neglect air resistance)*

1. A projectile is launched horizontally from a high platform with a velocity **v**. As the flight progresses,
a. what happens to the horizontal component v_x of its velocity?
b. what happens to the vertical component v_y of its velocity?
c. what happens to the speed v of the projectile?

2. a. Does a projectile experience *vertical* acceleration? If so, what causes it?
b. Does a projectile experience *horizontal* acceleration? If so, what causes it?

Section II: Smooth Operations

EQUATION MANIPULATION EXERCISES

INSTRUCTIONS: Solve the following exercises by writing out the appropriate equation, rearranging it and/or substituting given values into it as indicated. Diagrams may be helpful but are not required unless otherwise specified. Draw a box around your final answer. You may write solutions "two-across" on your paper (but no more than two across).

Uniform Accelerated Motion

3. Rewrite the equation $v = v_0 + at$
a. solving for v_0 b. solving for a c. solving for t

4. a. If $v_0 = 12$ m/s, $a = 2.0$ m/s^2, and $t = 8.0$ s, what is v?
b. If $v = 4.0$ m/s, $t = 12$ s and $a = -3.0$ m/s^2, what is v_0?
c. If $t = 8.0$ s, $v_0 = 0$, and $v = 32$ m/s, what is a?
d. If $a = 17$ m/s^2, $v = 133$ m/s, and $v_0 = 57$ m/s, what is t?

5. Rewrite the equation $x = {}^1/2(v_0 + v)t$
a. solving for v_0 b. solving for v c. solving for t

6. a. If $v_0 = 100$ m/s, $v = 10$ m/s, and $t = 9$ s, what is x?
b. If $x = 50$ m, $v = 20$ m/s, and $t = 8$ s, what is v_0?
c. If $x = 3$ m, $v = 1$ m/s, and $v_0 = 2$ m/s, what is t?

7. Rewrite the equation $v^2 = v_0^2 + 2ax$
a. solving for v b. solving for v_0 c. solving for a d. solving for x

8. a. If $v_0 = 8$ m/s, $a = 4$ m/s^2, and $x = 8$ m, what is v?
b. If $v = 16$ m/s, $a = 3$ m/s^2, and $x = 26$ m, what is v_0?
c. If $v_0 = 24$ m/s, $v = 0$, and $x = 50$ m, what is a?
d. If $v_0 = 13$ m/s, $v = 39$ m/s, and $a = 3$ m/s^2, what is x?

Projectiles / Range

9. Rewrite the range equation [$R = (v_0^2/g)\sin 2\theta$]
a. solving for v_0 b. solving for g c. solving for θ

10. Determine the range R of a projectile that has an initial speed of $v_0 = 100$ m/s and is fired at angles of
a. 10° b. 20° c. 30° d. 40° e. 50° f. 60° g. 70° h. 80°

11. a. Comment on the pattern revealed in the previous exercise.
b. Are there any differences between a projectile fired at 20° and one fired at 70°? If so, what are they?

12. a. If $R = 500$ m and $\theta = 20°$, what is v_0?
b. If $R = 200$ m and $v_0 = 50$m/s, what is θ? (Note: there are two complementary answers.)

13. A ball thrown with a speed v at an angle θ travels a distance R. How far—in terms of R—does a ball travel if thrown at the same angle but with an initial speed of $2v$ (i. e., does it travel $R/2$, or $2R$, or $4R$, etc.)?

14.‡ The squirting cucumber (*Ecballium elaterium*) is a fruit with a most extraordinary method of dispersing its seeds. It is about the size of a plum, and has a thick, thorny skin. Pressure is allowed to build up inside; when it has reached about 6 atmospheres, the fruit breaks away from the stalk and shoots off—like a rocket—firing its seeds backwards. Measurements show that it leaves at an angle of 50° to the ground with a speed of 10 m/s. Treat the cucumber as an ordinary projectile and calculate its range.

Section IV: Welcome to the Real World

APPLICATION PROBLEMS

INSTRUCTIONS: Solve the following problems as follows: 1. Draw a diagram, 2. List quantities, 3. Write base equation(s), 4. Rearrange equation(s), 5. Substitute quantities, 6. Write out (and box) final answer. No more than two problems may be solved on a single side of paper.

Average Speed

15. A car travels at 30 m/s for 120 s, at 20 m/s for the next 30 s, and finally at 25 m/s for 60 s. Find its average speed for the entire trip.

16. A woman jogs halfway to her destination at 6 m/s and walks the rest of the way at 4 m/s. What is her average speed for the entire trip? (Hint: It's **not** 5 m/s.)

17. A car covers one quarter of distance to the next town at 10 m/s, another quarter at 15 m/s, and the rest at 30 m/s. Find the car's average speed for the entire trip.

18. A man drives one-third the distance home at 7 m/s. How fast must he drive the rest of the way so that his average speed is 10 m/s?

Uniform Accelerated Motion

19. a. A car's speed increases from 8m/s to 20 m/s in 10 s. Find its acceleration.
b. The car's speed then decreases from 20 m/s to 10 m/s in 5 s. What is the acceleration now?

20. A Ferrari covers 100 m from a standing start in 6.0 s while undergoing a constant acceleration. Find its final speed.

21. A Porsche reaches a speed of 12 m/s from a standing start in 15 s. What distance does it cover while doing so?

22. A DC-8 airplane has a takeoff speed of 80 m/s, which it reaches 35 s after starting from rest. (*Hint: What is* a*?)*
a. How long does the plane take to go from rest to 20 m/s and what distance does it cover doing so?
b. How long does it take for the plane to go from 60 m/s to 80 m/s and what distance does it cover doing so?
c. What is the minimum length of the runway?

23. The brakes of a certain car produce deceleration with a magnitude of 5 m/s^2.
a. If the car is moving at 20 m/s when the brakes are applied, how far does the car travel in the first second afterward?
b. How far does the car go in the course of being slowed from 20 m/s to 10 m/s?

Free Fall (Neglect air resistance)

24. Divers in Acapulco, Mexico, leap from a point 36 m above the water. What is their speed when they hit the water?

25. A stone is dropped from a cliff 490 m above its base. How long does it take the stone to fall?

26. While vacationing in Yosemite, my brother Tom noticed that it took 4.5 s for water to fall from the top to the bottom of Vernal Falls and asked me if I could calculate the height of the falls from that information. "Of course," I beamed, "I'm a physicist!" We calculated the height in feet, using $g = 32$ ft/s^2.
a. What was our answer?
b. My other brother, Bryce, looked up the height in a travel guide and found it to be 318 ft. What was the percent error in our calculation? Was Tom's observation reasonable, or was he in error? (A reasonable observation is one that is within 10% of the accepted value.)
(%Error = $[| x_{CALC} - x_{ACTUAL} | / x_{ACTUAL}] \times 100$)

27. If you dropped a pencil from your desk (1.0 m above the floor)
a. how long would it take for the pencil to hit the floor?
b. how fast would it be going when it hit the floor?

28. In one of his brilliant scientific investigations, *Late Night* experimentalist David Letterman dropped a fully decorated wedding cake from his now-famous "5-story tower." If it took the cake 2.0 s to impact, what is the height of each story of Letterman's legendary monolith?

29. A ball is thrown upward with an initial speed of 9.8 m/s. What is its speed and direction
a. 1.0 s later? b. 2.0 s later?

30. A lead pellet is propelled upward at 16 m/s by an air gun. What is the maximum height it will attain before returning downward?

31. One Friday evening at a local fast-food venue, Devious Digby thought he would have some fun. So he took the pickle off his burger, dabbed some catsup on top and placed the pickle—catsup side up—in his palm. His “mission”: to fling the pickle up and allow it to adhere to the ceiling. Digby estimated the ceiling to be 2.5 m above him. What is the minimum initial speed Digby could give to the pickle and have it stick?

32. As always, Digby made the minimum effort in his “fling.” Actually, the ceiling was 2.6 m above Digby. Once the pickle gets to the top of its flight and doesn’t stick to the ceiling, how long does Digby have to get out of the way of the falling pickle (time of descent)?

33. A girl throws a ball vertically upward at 10 m/s from the roof of a building 20 m high.
a. How long will it take the ball to reach the ground?
b. How fast will it be moving when it hits the ground?

34. A girl throws a ball vertically downward at 10 m/s from the roof of a building 20 m high.
a. How long will it take the ball to reach the ground?
b. How fast will it be moving when it hits the ground?
c. How does the answer in part b compare to the answer to part b in the previous problem?

35. When a flea jumps, it accelerates through about 0.8 mm (a little less than the length of its legs) and is able to reach a height of as much as 10 cm.
a. Find the flea’s takeoff speed.
b. Find the flea’s acceleration (assumed constant) during takeoff.
c. When a person jumps, the acceleration distance is about 50 cm. If the acceleration of a person were the same as that of a flea, find the resulting takeoff speed.
d. Find the height of the person’s jump.

36. A helicopter is climbing at 8 m/s when it drops a water pump near a leaking boat. The pump hits the water 4.0 s afterward.
a. How high was the helicopter when the pump was dropped?
b. How high was the helicopter when the pump hit the water?

Projectile Motion *(Neglect air resistance)*

37. A bullet is fired horizontally from a height of 1.5 m. It lands 50 m downrange. What is the muzzle velocity of the gun?

38. A gun with a muzzle velocity of 250 m/s is aimed horizontally at a target 100 m away. How far will the bullet drop before hitting the target?

39. Legendary baseball pitcher Nolan Ryan could rifle a 100-mph fastball at a waiting batter. (Assume horizontal launch.)
a. How long was the ball in the air? (Distance = 60 ft, 1 mi = 5280 ft, $g = 32\ \text{ft/s}^2$)
b. How far (in feet) did the ball fall in that time?

40. A bomber is flying at an altitude of 8000 m at a speed of 250 m/s. At what horizontal distance ahead of its target must the bomb be released?

41. A rescue line is to be thrown horizontally from the bridge of a ship 30 m above sea level to a lifeboat 30 m away from the ship. At what speed should the line be thrown?

42. An airplane is in level flight at a speed of 120 m/s and an altitude of 1000 m when it drops a bomb. What is the speed of the bomb just as it hits the ground?

43. A ball is thrown horizontally to the right from the roof of a building 20 m high with a speed of 30 m/s. What will be the magnitude and direction of the ball's velocity when it hits the ground?

Range

44. Digby, throwing for maximum range, can throw a baseball 70 m. What was the ball's initial velocity? Give **v** in polar form.

45. A football is kicked such that its initial velocity is $\mathbf{v}_0$ = (20 m/s; 60˚). How far will the ball go?

46. Find the minimum initial speed of a champagne cork that pops for a horizontal distance of 11 m.

47. A blunderbuss can fire a slug 100 m vertically upward.
a. What is its maximum horizontal range?
b. With what speed will the slug hit the ground when fired upward and when fired so as to have maximum range?

48. A person can throw a ball a maximum distance of *L*. If the ball is thrown upward with the same initial speed, how high will it go?