College Physics
Exam 2 Homework Set
(Mathematical Preliminaries)
For physics students everywhere!

Wayne Hacker
Copyright ©Wayne Hacker 2009. All rights reserved.
Instructions:

All diagrams and figures on this homework are rough sketches: they are not generally drawn to scale. Your answers should be based on the numbers given, not on measurements made with a ruler or protractor.

This homework set consists of 60 multiple-choice problems. You are to be your own grader for the homework. You will find solutions to these problems on the website underneath the homework set itself. The solutions are broken into two parts: the answer key (i.e., just the answers), and on the following pages the worked out solutions. Since you have access to all of the solutions, I will not grade the homework.

The idea is that you should work the problems, then circle the answers on the grade sheet that is located on page two of the homework. When you are finished with a section, you should then compare your solutions to the answers on the answer key of the corresponding homework solution set.

If you miss any of the problems, then you should look up the solution, check to see what you did wrong, and correct it. You should keep track of which problems you miss. A good way to do this is to take the grade sheet with your solutions on it and place a large red X on the number of the problem that you missed.

If you don’t understand the solution, then you should seek help. If you miss lots of similar type problems, then you should go to my large problem bank and work more similar type problems.

You should do your work either on the space provided or on scratch paper and then recopy it over to a notebook or ringed binder. You should not try to squeeze your work onto the small space between the problems on this homework set.

This homework set is for practice only. It has no due date since I do not grade homework. However, if you write the solutions out with all of your work clearly labelled, neatly written, and all in one notebook or binder (a.k.a., a homework portfolio) as described in the syllabus, then I will take this into consideration should you find yourself on the border between two grades. I will not ask to see your portfolio until the end of the semester.
Directions: Work the problems, then circle your answers below.

1. a b c d e  
2. a b c d e  
3. a b c d e  
4. a b c d e  
5. a b c d e  
6. a b c d e  
7. a b c d e  
8. a b c d e  
9. a b c d e  
10. a b c d e  
11. a b c d e  
12. a b c d e  
13. a b c d e  
14. a b c d e  
15. a b c d e  
16. a b c d e  
17. a b c d e  
18. a b c d e  
19. a b c d e  
20. a b c d e  
21. a b c d e  
22. a b c d e  
23. a b c d e  
24. a b c d e  
25. a b c d e  
26. a b c d e  
27. a b c d e  
28. a b c d e  
29. a b c d e  
30. a b c d e  
31. a b c d e  
32. a b c d e  
33. a b c d e  
34. a b c d e  
35. a b c d e  
36. a b c d e  
37. a b c d e  
38. a b c d e  
39. a b c d e  
40. a b c d e  
41. a b c d e  
42. a b c d e  
43. a b c d e  
44. a b c d e  
45. a b c d e  
46. a b c d e  
47. a b c d e  
48. a b c d e  
49. a b c d e  
50. a b c d e  
51. a b c d e  
52. a b c d e  
53. a b c d e  
54. a b c d e  
55. a b c d e  
56. a b c d e  
57. a b c d e  
58. a b c d e  
59. a b c d e  
60. a b c d e
Mathematical Preliminaries

Introduction to Measurement

Dimensional consistency

Problem 1. Consider the formulas (i) and (ii). Are the formulas dimensionally consistent? Here $V = \text{volume}$, $v = \text{velocity}$, $x = \text{distance}$, $z = \text{distance}$, and $t = \text{time}$.

\begin{align*}
(i) \quad V &= x^2z \\
(ii) \quad v &= \frac{x-z}{t}
\end{align*}

(a) (i) is dimensionally consistent; (ii) is dimensionally inconsistent \\
(b) (i) is dimensionally inconsistent; (ii) is dimensionally consistent \\
(c) (i) and (ii) are both dimensionally consistent \\
(d) (i) and (ii) are both dimensionally inconsistent \\
(e) none of these

Problem 2. Consider the formulas (i) and (ii). Are the formulas dimensionally consistent? Here $a = \text{acceleration}$, $v = \text{velocity}$, $x = \text{distance}$, and $t = \text{time}$.

\begin{align*}
(i) \quad a &= \frac{x}{t-t_0} \\
(ii) \quad v &= a(t-t_0)
\end{align*}

(a) (i) is dimensionally consistent; (ii) is dimensionally inconsistent \\
(b) (i) is dimensionally inconsistent; (ii) is dimensionally consistent \\
(c) (i) and (ii) are both dimensionally consistent \\
(d) (i) and (ii) are both dimensionally inconsistent \\
(e) none of these

Problem 3. Consider the formulas (i) and (ii). Are the formulas dimensionally consistent? Here $a = \text{acceleration}$, $V = \text{volume}$, $x = \text{distance}$, and $t = \text{time}$.

\begin{align*}
(i) \quad a &= \frac{x^2}{t-t_0} \\
(ii) \quad V &= xy^2
\end{align*}

(a) (i) is dimensionally consistent; (ii) is dimensionally inconsistent \\
(b) (i) is dimensionally inconsistent; (ii) is dimensionally consistent \\
(c) (i) and (ii) are both dimensionally consistent \\
(d) (i) and (ii) are both dimensionally inconsistent \\
(e) none of these
Problem 4. Consider the formulas (i) and (ii). Are the formulas dimensionally consistent? Here $A = \text{area}$, $r = \text{distance}$, $x = \text{distance}$, $t = \text{time}$, and $v = \text{velocity}$.

(i) $A = 4\pi r^2$

(ii) $v = \frac{x}{t}$

(a) (i) is consistent; (ii) is not
(b) (ii) is consistent; (i) is not
(c) Both (i) and (ii) are consistent
(d) Neither (i) nor (ii) is consistent
(e) none of these

Problem 5. Determine whether equations (i) and (ii) below are dimensionally consistent.

(i) $x = at^2 + (1 + (vt)/x)^2$

(ii) $v_f^2 = v_i^2 + 2ax$

where $x = \text{distance}$, $v = \text{velocity}$, $t = \text{time}$, $a = \text{acceleration}$, $r = \text{distance}$, $g = \text{magnitude of gravity}$ and $\mu_s$ is the coefficient of static friction.

(a) (i) is dimensionally consistent; (ii) is dimensionally inconsistent
(b) (i) is dimensionally inconsistent; (ii) is dimensionally consistent
(c) (i) and (ii) are both dimensionally consistent
(d) (i) and (ii) are both dimensionally inconsistent

Problem 6. (Using dimensional analysis to get statistical-partial credit)

Consider the following test question and multiple-choice answers. Without knowing how to solve the problem, can you identify the answer that cannot be a solution based solely on dimensional analysis?

You are towing a crate of physics books down the hallway, using a rope that makes an angle of $\theta$ to the horizontal. The crate has a mass of $m$; the coefficient of kinetic friction between the crate and the floor is $\mu_k$. As you go down the hallway, you are giving the crate a forward acceleration of $a$. What is the tension $T$ in the rope, expressed in terms of the mass $m$, the acceleration $a$, the angle $\theta$ (dimensionless), $\mu_k$ (dimensionless), and the gravitational constant of acceleration $g$?

(a) $(mg\mu_k + a)\cos\theta$

(b) $\frac{m(g\mu_k + a)}{\cos\theta + \mu_k \sin\theta}$

(c) $\frac{m(g\mu_k + a)}{\cos\theta}$

(d) $(mg\mu_k + a)(\cos\theta + \mu_k \sin\theta)$

Problem 7. To get to your physics class in time, you must bicycle across town at an average speed of 13 miles per hour. What is this speed in meters per second? Round your answer to the nearest 0.1 m/s.

(a) 5.8 m/s

(b) 6.4 m/s

(c) 7.0 m/s

(d) 7.7 m/s

(e) none of these
Problem 8. In a desperate bid for extra credit, you install a 42-foot statue of your physics instructor at the college entrance. What is the statue’s height in meters? Round your answer to the nearest meter.

(a) 13 m  (b) 19 m  
(c) 92 m  (d) 138 m  
(e) none of these

Problem 9. You are given a ticket for driving at 38 miles per hour in a school zone. What is your speed in meters per second? Round your answer to the nearest m/s.

(a) 15 m/s  (b) 17 m/s  
(c) 19 m/s  (d) 20 m/s  
(e) none of these

Scientific notation

Problem 10. Convert the number 0.0070 to scientific notation. Your answer should have the appropriate number of significant figures.

(a) 7.0 × 10^{-2}  (b) 7.0 × 10^{-3}  
(c) 7.0000 × 10^{-2}  (d) 7.0000 × 10^{-3}  
(e) none of these

Problem 11. Convert the number 97,000 to scientific notation. Your answer should have three significant figures.

(a) 9.70 × 10^{3}  (b) 9.70 × 10^{4}  
(c) 9.7 × 10^{3}  (d) 9.7 × 10^{4}  
(e) none of these

Problem 12. Convert the number 6.2 × 10^{3} from scientific notation to standard form.

(a) 0.0062  (b) 6200  
(c) 0.062  (d) 62,000  
(e) none of these

Significant figures

Problem 13. How many significant digits are there in: \( v = 0.0420 \text{ m/s} \)?

(a) 2  (b) 3  
(c) 4  (d) 5  
(e) none of these
Problem 14. How many significant digits are there in: $y = 0.0504$ cm?

(a) 2  (b) 3  
(c) 4  (d) 5  
(e) none of these

Problem 15. How many significant digits are there in: $r = 0.001000$ m?

(a) 1  (b) 2  
(c) 3  (d) 4  
(e) None of these

Problem 16. Calculate $\frac{3.21}{55.77} + 16$. Round your answer to the correct number of significant figures.

(a) 16  (b) 16.0  
(c) 16.1  (d) 16.06  
(e) none of these

Problem 17. Calculate $\frac{122.1}{3.2}$. Round your answer to the correct number of significant figures.

(a) 38  (b) 38.1  
(c) 38.2  (d) 38.16  
(e) none of these

Problem 18. Calculate $120.51 + 3.2$. Round your answer to the correct number of significant figures.

(a) 120  (b) 124  
(c) 123.7  (d) 123.71  
(e) none of these

Arc length

Problem 19. An angle measures $87^\circ$. Use a calculator or equivalent to find its measurement in radians. Round your answer to the nearest 0.01 rad.

(a) 3.04 rad  (b) 0.38 rad  
(c) 1.52 rad  (d) 6.07 rad  
(e) none of these
Problem 20. An angle measures $22^\circ$. What is its measurement in radians?

(a) $\frac{22 \cdot 360}{\pi}$ rad  
(b) $\frac{22}{2\pi}$ rad  
(c) $\frac{22\pi}{180}$ rad  
(d) $\frac{22\pi}{360}$ rad  
(e) none of these

Problem 21. An angle measures $80^\circ$. Use a calculator or equivalent to find its measurement in radians. Round your answer to the nearest 0.01 rad.

(a) 1.40 rad  
(b) 1.54 rad  
(c) 1.69 rad  
(d) 1.86 rad  
(e) none of these

Problem 22. An angle measures 0.80 rad. Use a calculator or equivalent to find its measurement in degrees. Round your answer to the nearest degree.

(a) 46$^\circ$  
(b) 50$^\circ$  
(c) 55$^\circ$  
(d) 61$^\circ$  
(e) none of these

Problem 23. An angle measures 3 radians. What is its measurement in degrees?

(a) $\frac{(3)(180)}{\pi}$ degrees  
(b) $\frac{3}{2\pi}$ degrees  
(c) $\frac{(3)(360)}{\pi}$ degrees  
(d) $\frac{3\pi}{360}$ degrees  
(e) none of these

Problem 24. An angle measures 1.06 radians. What is its measurement in degrees?

(a) $\frac{1.06\pi}{180}$ degrees  
(b) $\frac{(1.06)(90)}{\pi}$ degrees  
(c) $\frac{1.06}{2\pi}$ degrees  
(d) $\frac{(1.06)(180)}{\pi}$ degrees  
(e) none of these

Problem 25. In the figure at right, if $\theta = 1/3$ rad, what is the arc length $s$?

(a) $\pi/18$ cm  
(b) $\pi/2$ cm  
(c) 2 cm  
(d) 18 cm  
(e) none of these
Problem 26. In the figure at right, what is the measure of the angle $\theta$?

(a) $\sqrt{14}$ rad  
(b) $5\pi/7$ rad  
(c) $5/7$ rad  
(d) $7/5$ rad  
(e) none of these

Problem 27. In the figure at right, what is the measure of the angle $\theta$?

(a) $4\pi/5$ rad  
(b) $5/4$ rad  
(c) $3$ rad  
(d) $3/\pi$ rad  
(e) none of these

Problem 28. A circle has a radius of 10 cm. A central angle $\theta$ intercepts an arc whose length is $4\pi$ cm. What is the measure of $\theta$?

(a) $5/2$ rad  
(b) $5\pi/2$ rad  
(c) $2/5$ rad  
(d) $2\pi/5$ rad  
(e) none of these

Problem 29. A circle has a radius of $3\pi$ cm. A central angle $\theta$ intercepts an arc whose length is 4 cm. What is the measure of $\theta$?

(a) $3/4$ rad  
(b) $3\pi^2/4$ rad  
(c) $4/3\pi$ rad  
(d) $4/3$ rad  
(e) none of these

Problem 30. A circle has a radius of 5 cm. A central angle has measure $\theta = \pi/3$ rad. What is the length of the arc intercepted by the angle?

(a) $2/15$ cm  
(b) $5\pi/3$ cm  
(c) $5/3$ cm  
(d) $10\pi/3$ cm  
(e) none of these

Problem 31. A spider is clinging to the blade of a ceiling fan, 18 cm from the center. If the fan turns through an angle of 2.1 radians, how far does the spider travel? Round your answer to the nearest cm.

(a) 9 cm  
(b) 18 cm  
(c) 27 cm  
(d) 38 cm  
(e) none of these
Problem 32. A physics instructor is riding on a merry-go-round, 2.3 m from the center. If the physics instructor travels a distance of 4.1 m, what angle has the merry-go-round turned through? Round your answer to two significant figures.

(a) 0.56 rad  
(b) 0.82 rad  
(c) 1.2 rad  
(d) 1.8 rad  
(e) none of these

Trigonometry

Problem 33. Use a calculator or equivalent to find cos(0.70 rad). Round your answer to three decimal places.

(a) 0.558  
(b) 0.620  
(c) 0.688  
(d) 0.765  
(e) none of these

Problem 34. Use a calculator or equivalent to find sin 77°. Round your answer to three decimal places.

(a) 1.026  
(b) 0.031  
(c) 0.331  
(d) 0.974  
(e) none of these

Problem 35. Use a calculator or equivalent to find tan 35°. Round your answer to three decimal places.

(a) 0.474  
(b) 0.576  
(c) 0.700  
(d) 0.851  
(e) none of these

Problem 36. Use a calculator or equivalent to determine the value of θ if θ is an acute angle and sin θ = 0.31. Round your answer to the nearest degree.

(a) 13°  
(b) 15°  
(c) 16°  
(d) 18°  
(e) none of these

Problem 37. Use a calculator or equivalent to determine the value of θ if θ is an acute angle and tan θ = 0.40. Round your answer to the nearest degree.

(a) 22°  
(b) 24°  
(c) 26°  
(d) 29°  
(e) none of these
Problem 38. Use a calculator or equivalent to determine the value of $\theta$ if $\theta$ is an acute angle and $\cos \theta = 1.19$. Round your answer to the nearest degree.

(a) 21°  (b) 50°  (c) 53°  (d) No such angle  (e) none of these

Problem 39. In the figure at right, $\cos \theta = ?$

(a) $t/s$  (b) $s/t$  (c) $u/s$  (d) $s/u$  (e) none of these

Problem 40. In the figure at right, $\cos \phi = ?$

(a) $y/r$  (b) $r/x$  (c) $x/r$  (d) $x/y$  (e) none of these

Problem 41. In the figure at right, $2/a = ?$

(a) $1/\tan \theta$  (b) $1/\cos \theta$  (c) $\sin \theta$  (d) $\cos \theta$  (e) none of these

Problem 42. In the figure at right, use a calculator or equivalent to find $a$. Round your answer to two significant figures. (The figure is not necessarily drawn to scale.)

(a) 4.5  (b) 6.0  (c) 6.7  (d) 7.8  (e) none of these

Problem 43. In the figure at right, use a calculator or equivalent to find $\phi$. Round your answer to the nearest degree. (The figure is not necessarily drawn to scale.)

(a) 24°  (b) 36°  (c) 49°  (d) 57°  (e) none of these
Problem 44. A pole is supported by a diagonal guy wire. The wire attached to the pole 5 m above ground level, and is anchored in the ground 8 m from the base of the pole. At what angle $\theta$ does the wire meet the ground? Round your answer to the nearest degree.

(a) $32^\circ$  
(b) $39^\circ$  
(c) $51^\circ$  
(d) $58^\circ$  
(e) none of these

Problem 45. You want to know the width of a river. You begin by standing directly across from a tree on the opposite bank. You then walk 400 ft straight downstream. From this new point, the tree is at an angle of $\theta = 60^\circ$ to the upstream direction. How wide is the river? Round your answer to two significant figures.

(a) 130 ft  
(b) 230 ft  
(c) 690 ft  
(d) 1200 ft  
(e) none of these

Problem 46. If $\theta = 190^\circ$, which quadrant is it in?

(a) Quadrant I  
(b) Quadrant II  
(c) Quadrant III  
(d) Quadrant IV

Problem 47. If $\theta$ is in the third quadrant, which of the following is true?

(a) $\sin \theta \leq 0$ and $\cos \theta \leq 0$  
(b) $\sin \theta \leq 0$ and $\cos \theta \geq 0$  
(c) $\sin \theta \geq 0$ and $\cos \theta \leq 0$  
(d) $\sin \theta \geq 0$ and $\cos \theta \geq 0$
Vectors

Problem 48. Which of the vectors below corresponds to $\vec{A}$ on the graph at right?
(a) $\langle -1, 2 \rangle$  
(b) $\langle -2, -1 \rangle$
(c) $\langle -1, -2 \rangle$  
(d) $\langle -2, 1 \rangle$

Problem 49. Which of the vectors in the graph corresponds to $-10\hat{i} + 5\hat{j}$?
(a) $\vec{A}$  
(b) $\vec{B}$
(c) $\vec{C}$  
(d) $\vec{D}$

Problem 50. Which of the vectors in the graph corresponds to $\langle 6, -3 \rangle$?
(a) $\vec{A}$  
(b) $\vec{B}$
(c) $\vec{C}$  
(d) $\vec{D}$
(e) none of these
Problem 51. The vectors $\vec{X}$, $\vec{Y}$, and $\vec{Z}$ are labelled on the figure at right. Which of the following equations is true?

(a) $\vec{Z} = \vec{X} - \vec{Y}$  
(b) $\vec{Z} = \vec{Y} - \vec{X}$  
(c) $\vec{Z} = \vec{X} + \vec{Y}$  
(d) $\vec{Z} = -\vec{X} - \vec{Y}$  
(e) none of these

Problem 52. The vectors $\vec{A}$, $\vec{B}$, and $\vec{C}$ are labelled on the figure at right. Which of the following equations is true?

(a) $\vec{C} = \vec{A} + \vec{B}$  
(b) $\vec{C} = \vec{A} - \vec{B}$  
(c) $\vec{C} = \vec{B} - \vec{A}$  
(d) $\vec{C} = -\vec{A} - \vec{B}$  
(e) none of these

Problem 53. $\vec{X} = \langle 1, -3 \rangle$ and $\vec{Y} = \langle -4, 5 \rangle$. Find $\vec{X} + \vec{Y}$.

(a) $\langle 4, -9 \rangle$  
(b) $\langle 5, -8 \rangle$  
(c) $\langle -2, 1 \rangle$  
(d) $\langle -3, 2 \rangle$  
(e) none of these

Problem 54. $\vec{X} = \langle 1, -3 \rangle$ and $\vec{Y} = \langle -4, 5 \rangle$. Find $\vec{X} - \vec{Y}$.

(a) $\langle 4, -9 \rangle$  
(b) $\langle 5, -8 \rangle$  
(c) $\langle -2, 1 \rangle$  
(d) $\langle -3, 2 \rangle$  
(e) none of these

Problem 55. If $\vec{A} = 2.0\hat{i} + 3.0\hat{j}$, what is the direction of $\vec{A}$? Round your answer to the nearest degree.

(a) $34^\circ$  
(b) $42^\circ$  
(c) $48^\circ$  
(d) $56^\circ$  
(e) none of these
Problem 56. If $\vec{A} = 2.2\hat{i} + 3.4\hat{j}$, what is the magnitude of $\vec{A}$? Round your answer to two significant figures.

(a) 4.0  (b) 4.5
(c) 4.9  (d) 5.4
(e) none of these

Problem 57. At exactly 12:00, a spider climbs onto the tip of a clock’s minute hand, where it remains for the next hour. Which of the vectors on the figure at right is in the direction of the spider’s displacement vector at 12:30?

(a) The zero vector $\vec{0}$  (b) $\vec{A}$
(c) $\vec{B}$  (d) $\vec{E}$
(e) none of these

Problem 58. Consider the statements (i) and (ii). Are the statements true or false?

(i) If $k$ is a scalar, then $k + k = 2k$
(ii) Let $\vec{v} = \langle a, b \rangle$. If $\|\vec{v}\| > 0$, then $a > 0$ and $b > 0$.

Choose the correct answer from below.

(a) (i) is true; (ii) is false  (b) (i) is false; (ii) is true
(c) Both statements are true  (d) Both statements are false

Problem 59. You are riding a motorcycle at a speed of 45 miles per hour, up a mountain road that slopes upward at an angle of 13° to the horizontal. What is the vertical component of your velocity? Round your answer to the nearest mile per hour.

(a) 8 mi/hr  (b) 9 mi/hr
(c) 10 mi/hr  (d) 11 mi/hr
(e) none of these

Problem 60. A gun is fired at an elevation of 22° above the horizontal. The shell emerges from the muzzle at 350 m/s. What is the vertical component of the shell’s velocity? Round your answer to the nearest 10 m/s.

(a) 130 m/s  (b) 180 m/s
(c) 240 m/s  (d) 320 m/s
(e) none of these