PHYS 121: Guidelines and Examples for Doing Homework Problems

16 January 2024

We find that students who start an introductory class in physics have a wide range of experiences and preconceptions about how written homework problems should be prepared and presented. In an effort to encourage best practices right from the start, we are including here a set *homework guidelines* plus a set of **three good example problems** that might have been included in the first homework. All of these problems follow these Good Homework Guidelines below. We also include an example page that includes homework that mimics work submitted by real students in the past where I have highlighted a few **weak practices for students to avoid.** Please check these out *before* you start work on the first homework.

It's also important to explain that these guidelines are just that; **these are guidelines, and not rigid rules**. In this class homework is meant to me a largely formative assessment tool where we ask student to **learn by doing**. This is why the weekly homework counts for a relatively small fraction of points in the course (15 percent of your grade) and this is why we use a comparatively relaxed fixed-point grading scheme (15 points per week, 13.0/15 points or higher is equivalent to an A; 10.5/15 or higher = B, 8.0/15 or higher = C, 5.5/15 or higher = D). This arrangement also tells you that we do not expect perfect work on the homework. ***We are looking for engagement that leads to understanding as demonstrated by your work.*** The grader is not out to get you. The grader is not just looking for any excuse to take away your points. Instead the grader is instructed to asses the overall quality of your effort and engagement which will lead to understanding of the work and to provide helpful feedback. Most students who take time to do the homework on a regular basis will find the effort rewarding to both their understanding of the material and to their grade in the course. Last year the average weekly homework score was about 13.5 points, a small grade boost for most students. The whole idea of the homework is to award enough points so that students feel motivated to do the work, but not so many points that students worry about their performance.

In the same vein, the guidelines below are designed to help students improve their homework and to get more out of doing it. Graders have been told to "reward" students who generally follow best practices as outlined by these guidelines and they have also been told that they should feel free to remove points from students who habitually and consistently present homework in ways that make the work hard to grade, follow, mark-up and/or understand. The point here is that you should read and apply the guidelines to help you improve your homework but do not obsess or stress about these guidelines.

One last thing: because of the large size of the class and the fact that the written homework is graded for both presentation, method, coherence and accuracy, **not every problem will be graded**. On average, a given weekly written homework will include between five and nine problems. Usually we will grade three to five of these. In other words, there's about a 50/50 chance that we will actually grade any given problem. However, students cannot predict in advance which particular problems we will grade. Therefore, we strongly encourage students to complete all of problems assigned for each homework.

Some General Advice for Preparing to Tackle the Homework:

Here are a few general pointing for "how to prepare and get started" in terms of the Written Homework.

- It's always a good idea to **read through the homework** as soon as possible when it is posted. Your first read-through should correspond to "skimming" to get a general idea of the kinds of questions that you are looking at. Specifically, try to identify the **Central Main Physics Concept** that applies to each problem, if you can. Every homework problem is specifically designed to address a Main Physics Concept. So usually the first step in solving any problem is correctly identifying that concept.

  For example, perhaps the central concept is "1-D Kinematic with Constant Acceleration." Or perhaps it is "Newton's Second Law with Free Body Diagrams." Etc. If you cannot immediately identify the central physics concept for a given problem make a note and then "be on the lookout" when you go through the course materials to identify the concepts that you need.

- Make sure you are clear on the deadlines and have planned some time in the coming week to work through the homework. Our hope and expectation is that most students will take between four and six hours per week to complete the homework for Physics 121.

- I generally recommend that students take a careful look at the **Review Sheet** documents that apply to each homework set. **The Review Sheets represent a list of the main physics concepts and methods in compact form.** As a rule, if you are not sure which concept applies to a given problem look for it in the relevant Review Sheets. For example, **Homework #01** includes problems each of which relates to one or more of the main concepts that are delineated in **Course Document #04: Cycle 1 Review Sheet, Part 1**. My recommendation is that you actually print a hardcopy of the Review Sheet (it's a PDF file) and have this in front of you when you are working the homework.

- Decide for yourself a plan for "covering the material" in terms of some mix of the assigned readings, lecture notes and other materials. Some students worth methodically through all of the materials. Others skim once and then come back to find details while working the problems. Whatever style works for you, make a plan that fits the time you have available. Remember, the most important ideas are in the Review Sheet. The readings are designed to fill in and explain in more detail about these concepts.

- Most weeks we are likely to post a set of **Hints on Homework** that can be found on Canvas. If you are not confident about how to proceed through the problems, then you are likely to benefit from the posted hints.

- During the semester we will occasionally post practice problems. We also work some practice problems in lecture. Some of these provide good examples and are tutorial for doing the homework problems.

- . If you get stuck on homework, there are lots of sources for help. We encourage students to consult with peers, including other students and peer tutors. Another source of help is instructor's office hours. Finally, the SI Leader will organize a weekly homework help session that you can plan to attend.

- One last thing. After each homework is collected we post a typeset solution set. You should study these solution and compare your graded homework against the solutions. For each problem make sure you understand the solutions and make sure you understand any marks or comments from the grader. ***The typeset homework solutions are of central importance in the course and effective correspond to "require reading" in preparation for exams.*** Even if you do scored well on the homework, be sure to plan to study the typeset solutions.

Homework Guidelines continue next page...

Important Written Homework Guidelines:

1. Important: These guidelines are just that; **these are guidelines, and not rigid rules**.

2. **Explain your work.** This is the single more important rule for graders who are looking at student work for Physics 121 **The correct answer alone on Written Homework is worth nothing.** Zero. Nada. This is true on homework, it is true on exams. You absolutely *must* explain what you are doing. This is not optional. Your explanation *must* include a short sentence or two. **When we say "explain your work" we don't need a paragraph.** Just a sentence or two. Or perhaps even just a few key words. The way to "decode" the statement "explain your work" is to as "Please identify the main physics concepts as you apply and use them." This means when you use Newton's Second Law be sure to write down the words "Newton's Second Law" and not just F=ma. Yes the equations are important, but equations and numbers are simply not enough. You must do more than simply writing down an equation and solving it. **A bunch of equations and number with no explanation at all unacceptable for both homeworks and exams.** Your explanation is considered a pedagogically critical component of your answer and the the grader will look for it. When you explain your work, you demonstrate to yourself and to the grader that you really know what you are doing, that you have mastered this work, and that you are not just somehow fooling yourself into thinking that you can solve the problem.

   What do the explanations need to include? Here's the main idea: Always ask yourself: **"What is the fundamental physics concept, here?"** You must answer this question for every problem and you must articulate that concept in words as part of your written explanation when you write down your solution. This is the most important guideline of all.

3. Please scan your homework from $8\frac{1}{2} \times 11$ sheets (or paper of approximately this size). You may use lined or un-lined paper. Please do not use colored paper. Yes, you may use a "pad" to complete your homework, but the output must be "printable" as a standard letter-sized page of paper, easy to read and not crowded into one area.

4. Please write your full name on the top sheet, just as it appears in your university registration. Please write your name legibly, in block letters, so we can easily read it. Every year some students miss credit for homework because we cannot read or find their names on the top page of their homework.

5. Please also write at the top of your home your shorthand case "Case Network Id" (something like "kxk32") on your homework. This *really* helps with record keeping and in case something gets misplaced and/or in case students have similar names.

6. Also please write down the course name and assignment numbered. For example, your first written homework should have at the top of the first page the words "PHYS 121: Written Homework #01" or something like this.

7. **Your work must be correctly ordered and scanned as clear, legible, and high-contrast PDF file.** Please use ***Camscanner*** or some similar app to convert your written document to

a PDF file that you can upload to Canvas. **A single PDF corresponding to a printable file that is clear and legible with each problem clearly marked in dark readable writing on white background is the only acceptable format for submitting written homework.** You must submit homework via Canvas – do not send homework to the instructors by email. If you use a very light pencil you must use an app that enhances the contrast so that the grader can read your work. Avoid shadows or taking pics of your work in dark areas which makes the work hard to read. Write large enough so that the grade can read your work. Work that is too crowded or too light to read may be returned without being graded. Be sure that your PDF document can be read by the grader before you submit your work. **Check that the file you uploaded to Canvas can be easily read and displayed on Canvas.** If you cannot read your own work, neither can the grader.

8. If appropriate, include a diagram showing what is going on in the problem. Again, anything that you put down that shows the grader what you are thinking, that demonstrates that you understand conceptually what is going on, this is a good thing. Physics concepts, diagrams, explanatory words, all good. Unexplained algebra, plug-and-chug, not good. The whole point is to demonstrate to the grader that you understand the process of moving from the main concept through to the solution.

9. **Important: Neatness counts.** Your work must be cleanly and clearly organized so that the grader can follow your logic. There should be a coherence and logical flow. Sloppy work will be down-graded. Graders are instructed to remove points for disorganized, sloppy, smeared, illegible, incoherent, or inscrutable written work. We are not looking for perfection here, but if the grader cannot easily read and understand what you have done then you will lose points. If this is a problem for you, consider writing up your solutions on a computer instead of by hand.

10. **Extremely Important: Do not crowd your work! Leave lots of extra "white space" for the grader to mark and comment on your work. Please! This is Really Important!** There are some students who really try to pack their work into the smallest possible space. Crowded work will be down-graded. Graders are instructed to remove points if there is inadequate space for marking comment. A good rule of thumb is to leave at least one inch margins on the side, at least one inch of space between parts of each problem. Leave lots of space around equations and math, especially. And most importantly, leave at least two inches of space between problems. Actually, as a rule I'd recommend that you put no more that one problem per sheet of paper and I also usually suggest that you write your solutions on only one side of the sheet. If the idea of "wasting" this much paper bothers you, please come see me during office hours and I will be glad to give you paper that is heading for the recycling bin.

11. Write down the source of any equations that you might introduce and/or and tell us why you chose to use them – e.g., is there some central guiding principle or concept? Every problem we assign is assigned for the purpose of exploring a central physics concept. You must identify that concept for every problem. Every "equation" that you can apply in this course derives from a central physics concept. You need to articulate that concept

when you introduce an equation. Please do not pull equations out of "thin air". It is very important that you and the grader have a clear picture of where your equations are coming from. Again, explain what you are doing, if only a few words will do it. For example if you use Newton's Second Law to solve a problem, write down words something like "Newton's 2nd Law" on your homework next to the equation. You can use abbreviations. You do not need to give a detailed paragraph. We do not even need complete sentences – but we absolutely do need just a few words – not equations – to explain your work on every problem.

12. As a rule, **work out the solution to every problem in terms of symbolic algebraic variables *before* you plug in any numerical values.** This one is often one of the most difficult for students in the class who may be used to working problems numerically instead of symbolically. In Physics 121 we will generally *insist* that you work out the problem symbolically first, before you plug in any numbers.

    What does this mean? It means that even when you are given a bunch of numbers in a problem, you need to first re-articulate those numbers as algebraic symbols, and then you need to find the solution in terms of those symbols. So unless the problem is numerically trivial, you must *always* solve the problem symbolically (with variables such as m and t and v_0 and θ, and give the requested answer in purely terms of these symbolic variables.

    Here's the guiding principle: **For Physics 121, the correct symbolic answer is much more important than the correct numerical answer.** So the graders will be looking for the correct symbolic answer and not the correct numerical answer. So make sure the grader can find your symbolic answer. **Put a box around your symbolic answer.** Then, after you have done this, you can continue and plug in any numeric values that you may have for these symbolic values (things like "15.5 kg" or such) and you may give the correct numerical answer. This is the "less important" final answer. Put a box around your numeric answer too.

    In other words, always solve *first* in terms of symbolic (variables) algebra. Always plug in the numbers as the *only as the very last step of the problem.* (The one exception to this rule is that you can always plug in the number "zero" if you know that a variable has this value). Symbolic variables are preferable to numeric values for many reasons, not the least of which it is guaranteed to please the grader and earn you more points. See the example problems.

13. If you are asked to produce a graph or a plot in homework, take the time to do this carefully and neatly! Important: Please use graph paper! Students who "rough hand sketch" a plot instead of using graph paper and/or making a careful plot with a ruler will certainly lose some points. Alternately, using computer plotting packages for neatness is encouraged. If you draw a plot by "hand", please be sure to put proper axis labels and scale. Be neat and complete! If you have any questions about how to properly make a graph get some help on this.

14. Important: if you make a plot or a graph, you *must explain where the values in the plot came from.* For example, it's usually a good idea to make a *table* of the numbers used in the plot and to put down some words explaining how you made the table. You need

to show how you did the calculations somewhere. A plot or a table with values that are correct but not explained will not get full credit. Likewise, if you use a plot or a graph to infer an answer, you have to explain what you did. For example, if you calculate the velocity by deriving the slope of a plot of position vs. time, you are obligated to explain how you calculated the slope. That explanation can be in words or with graphical marks on the plot, but you need to explain.

15. For your numeric answers, include the correct physical units. Do not report that the acceleration has a value of '4.53'. This is almost meaningless. Instead report that the acceleration is '4.53 meters per second squared' or better yet report that $a = 4.53$ m/s^2. Unless clearly indicated otherwise, use SI units (meters, seconds, kilogram, etc.) If you are not given SI units, then convert to SI units first and solve the problem in SI.

16. Report your numeric answer with an approximately appropriate number of significant digits. Many students use way too many significant digits because this is what the "read from their calculator." This is a bad habit and I will ask graders to consider taking off points points for this. If I state a problem with parameters given to only two or three significant digits, then it makes no sense to present a number with eight significant digits in your answers. The extra precision is not justified and you are really just wasting effort and pencil pushing for no good reason. Note: don't get hung up on significant digits. All I care is that you get the number of digits *approximately* correct. If the answer requires four significant digits and you put down 3, or 5, or even 6 digits then this is fine. Just don't put down 8 digits.

17. Please use exponential notation that is common usage in for the physical sciences, not "computer-speak", or other syntax, regardless of what you may have been taught elsewhere. In other words when the number in decimal is 123.0 you may write this as 1.23×10^2 but please do *not* write 1.23E2. Doing so will cause the graders to cringe. They will take away point if they see it too often.

18. Okay so this is a very very common issue: We often deal with vector quantities in this course. Vectors are mathematical objects that have both a magnitude (length) and a direction. The magnitude of a known vector is a (scalar) number with appropriate units. But a vector is not a number. A vector is not a scalar.

    When we write down a symbolic representation of a vector, we put a "little arrow" over the top of the algebraic symbol to indicate that we are talking about a vector. For example, if we want to talk about the net force on a body we might write down something like:

    $$\vec{F}_{net} = \vec{F}_1 + \vec{F}_1 + \vec{F}_3$$

    This means that the vector $\vec{F}_{net}$ is equal to the vector sum of three other vectors, $\vec{F}_1$, $\vec{F}_2$, and $\vec{F}_3$. This makes sense because each one of these things is a vector (not a number) and we have a special set of rules for "adding" vectors.

    Note that when we refer to the (numeric) magnitude of a vector, we *drop* the "little arrow". For example the *magnitude* of the net force is written as:

    $$F_{net} = |\vec{F}_{net}|$$

Note that F_{net} and $\vec{F}_{net}$ are not the same thing and are not interchangeable. $\vec{F}_{net}$ is a vector, it has magnitude and direction. It points somewhere. However, F_{net} is the magnitude of that vector. It is a scalar. It is a number. It doesn't point anywhere.

Students can be very sloppy about whether a given symbol should or should not have "little arrows" on it. It really matters. In PHYS 121 we must be very careful to do this correctly. For example it might be reasonably correct to say "The net force on the table $F_{net} = 45.0$ Newtons." In this case, when we say "the net force" this implies the magnitude of the net force, which is 45.0 Newtons. This is a number. But if I wrote instead: "The net force on the table $\vec{F}_{net} = 45.0$ Newtons," well this would be a wrong thing to say because $\vec{F}_{net}$ is a vector and it has no numeric value. Instead the correct thing to say is 'The net force on the table $\vec{F}_{net}$ has a magnitude $F_{net} = 45.0$ Newtons.

19. Please "adopt and adapt to" the force notation and syntax that we are using in this course. Students have a wide experience in prior physics courses as to the "right" way to represent a given force. I am not arguing that our way is "right" and best way, and I am not arguing that any different way you may have learned in the past is "wrong" – but I am telling you that you should plan to spend your college career adapting to whatever notation is being used in any given course.

    Here specifically is a short example list of some of the standard notations that we use for forces in PHYS 121:

    - $\vec{W}$ = A Weight Force. (We say "weight" not "gravity" in P121).
    - $\vec{N}$ = A Normal Force
    - $\vec{T}$ = A Tension Force
    - $\vec{f}$ = A Friction Force
    - $\vec{F}_{UG}$ = A Force of University Gravity
    - $\vec{F}_{app}$ = A given Applied force.
    - $\vec{W}_A$ = "The Weight Force *on* Body A."
    - $\vec{N}_{BT}$ = "The Normal Force *on* Body B *due* to the Table."
    - f_{AB} = "The magnitude of the Friction Force *on* Body A *due* to Body B."
    - F_c = "The magnitude of the *net* force in the *centripetal* direction."
    - F_{Ax} = "The magnitude of the *net* force on Body A in the x-direction."

Example Written Homework Problems and Solutions:

Example Problem 1. One of the empirical laws of planetary motion that was discovered by Kepler is known as the "harmonic law". For planets going around the Sun with near-circular orbits Kepler's Third Law says that the orbital period T is related to the orbital radius R as follows:

$$\frac{T^2}{R^3} = K = 1.00 \frac{\text{yr}^2}{\text{AU}^3}$$

where K is a constant. The Earth, for example, has an orbital period of 1.00 years and an average radius of very nearly 1.00 AU (astronomical units – see distance definitions on the inside cover of your text).

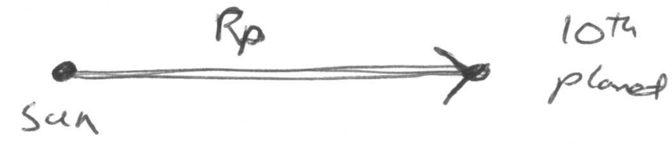
Suppose an astronomer discovers a planet outside the orbit of Pluto. Suppose the astronomer determines the orbital period of the new planet to be 343 years. Approximately how far away from the sun is this new planet? Give your answer in both AU and meters. Light travels at a speed of 3.0×10^8 m/s. How long does it take the light of the sun to travel to this new planet? Give you answer in seconds, and also in the most appropriate time units.

Example Problem 2. Here's an "ill-structured" problem". On a Saturday afternoon you pull into a parking lot with unmetered spaces near a shopping area. You circle around, but there are no empty spots. You decide to wait at one end of the lot from where you can see (and command) about 20 spaces. About how long do you have to wait before someone frees up a space?

Example Problem 3. Michael Jordan leaps for the basket. He has a vertical upward velocity of 2.8 meters per second when his feet leave the ground. How high in the air will he travel? How much time will elapse before he returns to the ground?

$\boxed{\text{Example Problem 1}}$

Diagram:



Use Kepler's Third Law!

$$\frac{T^2}{R^3} = K \qquad \text{where} \qquad K = 1.00 \frac{(yr)^2}{(AU)^3}$$

T = orbit Period

R = radius of orbit

$\Longrightarrow$ Solve for R_p given T_p

$$\Longrightarrow T_p^2 = K R_p^3 \Longrightarrow R_p^3 = \frac{T_p^2}{K} \Longrightarrow \boxed{R_p = \left(\frac{T_p^2}{K}\right)^{1/3}}$$

Plug in values: $R_p = \left[\frac{(343\ yr)^2}{1.00 \frac{yr^2}{(AU)^3}}\right]^{1/3} = \boxed{49\ AU}$

Converting to meters: $(49\ AU)\left(\frac{1.496 \times 10^{11} m}{AU}\right) = \boxed{7.3 \times 10^{12} m}$

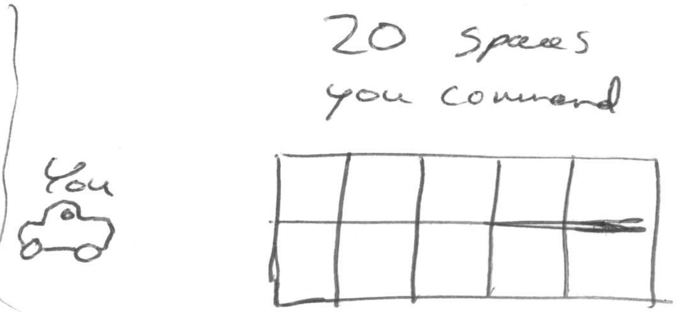
Light travel time = $\frac{\text{distance}}{\text{speed}}$

$$\Longrightarrow \boxed{t = \frac{R_p}{c}} = \frac{(7.3 \times 10^{12} m)}{(3 \times 10^8 m/s)} = \boxed{1.9 \times 10^4 s}$$

Recall that one hour = 3600 seconds so

$$t = (1.9 \times 10^4 s)\left(\frac{1\ hour}{3600 s}\right) = \boxed{5.3\ hours}$$

Example Problem 2



You command $N_c = 20$ spots. (Note the other spaces that you do not command are irrelevant to problem.

Time to wait is just usual time to wait for one spot divided by N_s (you have 20 times)

Average time to wait for one spot about 1/2 of time typical shopper is in store (1/2 because on average given shopper went into store "1/2-time" ago):

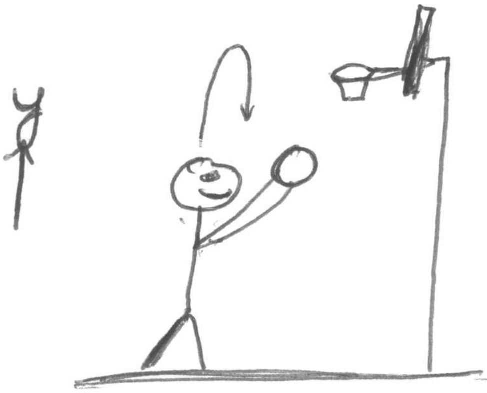
$$\boxed{N_{wait} \approx \frac{t_{shop}}{2N_c}}$$

Plug in #'s
estimate $t_{shop} = 2$ hours

$$= \frac{2 \text{ hours}}{2(20)} = \frac{1}{20} \text{ hour} = \boxed{3 \text{ minutes}}$$

So on average you will have to wait about 3 minutes to grab a spot if you command 20 spaces

Example Problem 3



$\Longrightarrow$ Treat Jordan as a "point mass" with initial position $y_0 = 0$ and initial vertical velocity: $v_0 = 2.8\ \text{m/s}$

$\Longrightarrow$ "Free Fall" kinematics $\rightarrow$ <u>constant acceleration</u>

Equations:

$$\Longrightarrow \quad v_y = v_0 - gt$$

$$\Longrightarrow \quad y = y_0 + v_0 t - \tfrac{1}{2} g t^2$$

At <u>top</u> of jump $\boxed{v_y = 0}$ so solve for t:

$$v_y = 0 = v_0 - gt \Longrightarrow t = \frac{v_0}{g}$$

We want height jumped. solve for y:

$$y = \cancel{y_0}^{\,0} + v_0 t - \tfrac{1}{2} g t^2$$

$$= v_0\left(\frac{v_0}{g}\right) - \tfrac{1}{2} g \left(\frac{v_0}{g}\right)^2 = \frac{v_0^2}{g} - \frac{v_0^2}{2g} = \boxed{\frac{v_0^2}{2g}}$$

plugging in numbers

$$y = \frac{v_0^2}{2g} = \frac{(2.8\ \text{m/s})^2}{2 \cdot (9.81\ \text{m/s}^2)} = \boxed{0.40\ \text{meters}}$$

Time to fall $= 2 \times$ (time to top) (by symmetry)

$$t_{Fall} = 2\, t_{top} = \boxed{\frac{2 v_0}{g}} = \frac{2(2.8\ \text{m/s})}{9.81\ \text{m/s}^2} = \boxed{0.57\ \text{seconds}}$$

Good Examples vs. Bad Example Homework

On the three previous pages are show good example solutions that model the kind of work we are looking for.

On the following page is a **bad example** homework. This page shows you some examples of *things to avoid* in your homework. Note that this page presents a solution to the same three example problem, and in fact the answers are "correct" but the work is peppered with bad method. Here is a list of at least some of problematic issues. Note that students who habitually present work with these sorts of problems can expect a reduced grade on the homework.

- **Problem 1:**
  - There is no diagram showing what is going on in the problem.
  - There are no words at all explaining the work or where the formula comes from. This is completely unacceptable.
  - Specifically, the **main physics concept** which is ***Kepler's Third Law of Planetary Motion*** is not mentioned or explained in any way.
  - Numeric values are "plugged in" to the equation and then (apparently) solved. The student should have solved the problem ***symbolically first***, and then numerically.
  - The student uses the "computer notation" (3.0E8) for the speed of light instead of 3.0×10^8.
  - The student does not use proper units. All numeric answers generally need to include units. (Symbolic answers have the units "built in" to the symbols).
- **Problem 2:**
  - The student just wrote down an "answer" with no explanation of how this was arrived at all. Even though it is the correct answer, the grader would be justified to assign *zero points* for this because no explanation whatsoever is given. Every homework answer, every exam answer needs at least a few words of explanation as to where the answer comes from.
- **Problem 3:**
  - Again no explanation, no diagram, just equations that come out of thin air. This is unacceptable.
  - Crazy too many significant digits.
  - No units on the numerical answer.
  - Again working algebra with numbers instead of symbols.

Physics Homework by JO F.U.

Problem 1

$$\frac{T^2}{R^3} = 1 \qquad \frac{(343)^2}{R^3} = 1 \quad R = 49$$

$$\text{speed} = \frac{\text{distance}}{\text{Time}} \Rightarrow 3.0E8 = \frac{49}{t}$$

$$\rightarrow t = \frac{49}{3E8} = 1.6333333E{-7}$$

Prob 2: I'd say he has to wait about 3 minutes.

Prob 3

$$v = v_0 - gt$$

$$0 = 2.8\,m/s - (9.81)t$$

$$\rightarrow t = \frac{2.8}{9.81} = 0.285714285714$$

Height

$$y = \cancel{y_0 +} v_0 t - \tfrac{1}{2} g t^2$$

$$= (2.8)(0.28571428514) - (2.8)(9.81)(0.0857142857)$$

$\approx$ About $\frac{1}{2}$ ~~[illegible]~~ meter

Free Fall = 0.57084607

QED