PHYS 615 – HW 1

Types of homework questions

- RQ (Reading questions): prompt you to go back to the text and read and think about the text more carefully and explain in your own words. While not directly tested in quizzes, can help you think more deeply about quiz questions.
- BF (Building foundations): gives you an opportunity to build and practice foundational skills that you have, presumably, seen before.
- TQQ (typical quiz questions): Similar questions (though perhaps longer or shorter) will be asked on quizzes. But the difficulty level and skills tested will be similar.
- Design (D): These are questions in which you are given a desired outcome and asked to figure out how to make it happen. These will often also be TQQ's, but always starting with desired motion/behavior as the given.
- COMP (Computing): computing questions often related to TQQ but will never be asked on a quiz (since debugging can take so long). You will need to do at least four computing questions over the semester
- FC (free choice): allows you to decide where to put your time. Any of the following are possible: work through a section of the text or a lecture in detail; redo a problem from before; do an unassigned problem in the text; extend a computing project; try a problem using a different analytical approach (e.g. forces instead of conservation of energy).

Full credit will be given at 75% of the total points possible, so you can choose a subset of problems (you can do more / all, but the score is capped at 75%)

1. COMP (10 points)) **–required–** *Prepare to code*.

   (a) Decide on a language (Python / Jupyter notebooks is recommended, but Matlab or other options are possible.)

   (b) Make sure you have a programming environment that you can work in.

   - Jupyter notebooks (though feel free to use another Python environment if you prefer it). Prof. Holtrop's intro to notebooks: https://github.com/mholtrop/phys601/tree/master/Notebooks
   - Matlab – google "UNH matlab student download" to get matlab on your computer

   Hand in code that plots the function $\sin(x)$ for x from 0 to 2π, using your preferred coding language. All code will be handed in to Canvas, since Gradescope only takes PDF and images, and I want to be able to try out your code.

2. BF (10 points) **–required–** *Taylor series.* Look at Equation (2.87) in Taylor (Taylor series). In what way is this expression different from or similar to Taylor series that you have seen in Calculus? What, if anything, is confusing about this equation?

   For those of you who do not have the text yet, here is the problem in Taylor:

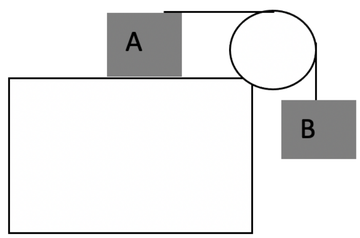
2.18 ⋆ Taylor's theorem states that, for any reasonable function $f(x)$, the value of f at a point $(x+\delta)$ can be expressed as an infinite series involving f and its derivatives at the point x:

$$f(x+\delta) = f(x) + f'(x)\delta + \frac{1}{2!}f''(x)\delta^2 + \frac{1}{3!}f'''(x)\delta^3 + \cdots \tag{2.87}$$

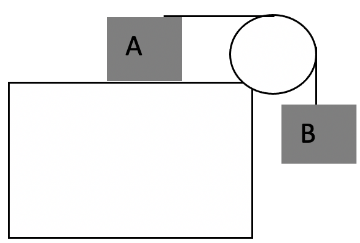
where the primes denote successive derivatives of $f(x)$. (Depending on the function this series may converge for *any* increment δ or only for values of δ less than some nonzero "radius of convergence.") This theorem is enormously useful, especially for small values of δ, when the first one or two terms of the series are often an excellent approximation.[11] **(a)** Find the Taylor series for $\ln(1+\delta)$. **(b)** Do the same for $\cos\delta$. **(c)** Likewise $\sin\delta$. **(d)** And e^δ.

3. BF/RQ (10 points) *Taylor series.* Read this page https://www.mathisfun.com/algebra/taylor-series.html about Taylor series. This is one of many topics that you "should have learned" in previous classes. But getting a deep understanding of math and physics takes significant time and effort. So here is an opportunity to deepen your understanding of this topic. Here, as in future homework, if you see a topic under "BF" that you are not feeling solid on, I strongly suggest that you do this problem.

4. TQQ, D (10 points) *Newton's Law problem.* This is a modified Atwood machine, with two blocks connected by a massless string over a massless pulley. Block A rests on a rough horizontal surface with coefficient of static friction μ_s. What is the maximum mass m_B for B that will allow the blocks to stay motionless? Give your answer in terms of m_A, g, and μ_s. Be sure to check your answer (units, expectations, limiting cases).



5. TQQ (10 points) *Newton's Law problem.* This is a modified Atwood machine, with two blocks connected by a massless string over a massless pulley. Block A rests on a rough horizontal surface with coefficient of kinetic friction μ_k. What is the acceleration of the system? Give your answer in terms of m_A, m_B, g, μ_k. Be sure to check your answer (units, expectations, limiting cases).



6. TQQ, D (20 points) *Newton's Law problem.* Block A rests on block B, and both slide down an incline with coefficient of kinetic friction μ_k. The coefficient of static friction between blocks A and B is μ_s. Assume that static friction is large enough to hold Block A still with respect to block B.

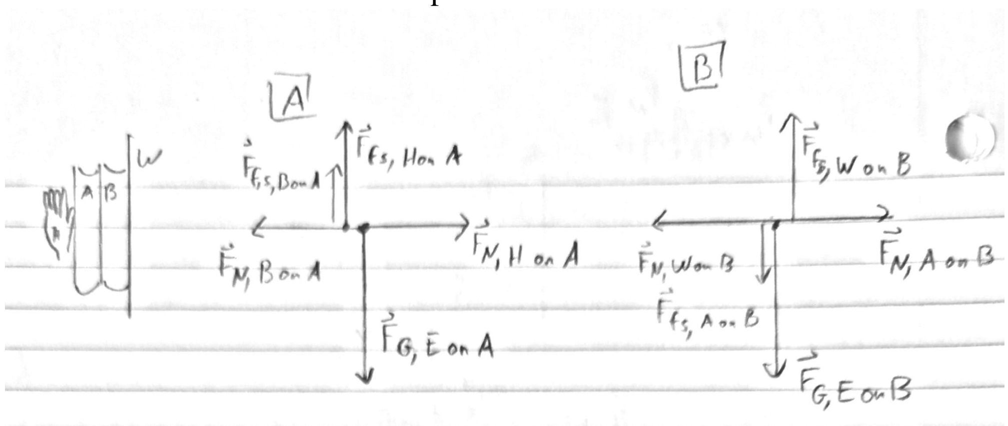
   (a) What is the acceleration of the system?

(b) How big must μ_s be to keep block A still with respect to block B?

(c) How big are all of the normal forces?

Give your answers in terms of m_A, m_B, g, μ_k. Be sure to check your answer (units, expectations, limiting cases). Hint: Example 1.1 in the book reminds you how to work with inclined planes.

7. TQQ (10 points) Consider a hand, pressed against vertical book A, which is in turn pressed against vertical book B, which is in turn pressed against a vertical wall; the books are at rest. There is static friction between all surfaces. Draw the free body diagrams for books A and B. State in words what the third law pairs are for each force on those books.



Third-law pairs: $\vec{F}_{N,B\,on\,A} = -\vec{F}_{N,A\,on\,B}$, $\vec{F}_{fs,B\,on\,A} = -\vec{F}_{fs,A\,on\,B}$, $\vec{F}_{N,H\,on\,A} = -\vec{F}_{N,A\,on\,W}$, $\vec{F}_{N,W\,on\,B} = -\vec{F}_{N,B\,on\,W}$, $\vec{F}_{fs,H\,on\,A} = -\vec{F}_{fs,A\,on\,H}$, $\vec{F}_{fs,W\,on\,B} = -\vec{F}_{fs,B\,on\,W}$, $\vec{F}_{G,E\,on\,A} = -\vec{F}_{G,A\,on\,E}$, $\vec{F}_{G,E\,on\,B} = -\vec{F}_{G,B\,on\,E}$.

The direction for the friction between A and B is not clear given what's known (could be zero, too, but those two are third law pairs, so whatever they are, they have to be equal and opposite).

8. TQQ (10 points) One argument against Newton's Third Law, is that if forces are equal and opposite, then forces will always be balanced and there is no motion. Take a particular simple situation (e.g., a hand accelerating a block on a rough table), draw the free body diagram of the block, identify all third law pairs to the forces acting on the block, and explain why this concern is unfounded.

9. FC (10 points) (free choice): allows you to decide where to put your time. Any of the following are possible: work through a section of the text or a lecture in detail; polish up a group work assignment from class; redo a problem from before; do an unassigned problem in the text; extend a computing project; try a problem using a different analytical approach (e.g. forces instead of conservation of energy).