Rules: This exam is to be completed by you unaided by textbook, web, notes, homework solutions, friends etc.... (You are of course encouraged to use a calculator.) The one external aid you may use during the exam is the unannotated 'Course Guide:' the formulas, definitions, etc that I recorded there may help you recall how to work a problem. If, during the exam, you think you need an additional formula or hint, ask me (via personal chat) and I may be willing to provide it. Remotes will enable video, have audio available but muted and be on screen 100% of the time. Questions may be asked via personal chat. You should also use the Hands Up feature to draw my attention to your question.

Clearly the above will hardly deter the determined cheater. Your personal integrity is the only real deterrent to cheating. To engage that, sign the below statement just before you turn in the exam.

In answering these questions I have not aided any other student or used any external aids other then the unannotated 'Course Guide'.

Name: ________________________________

Circle the letter of the single best answer. Each question is worth 1 point

Physical Constants:

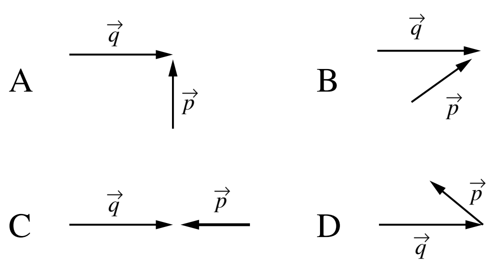
Earth's free-fall acceleration $= g = 9.80\ \mathrm{m/s^2}$

1. How many of the below numbers display exactly 3 significant digits?

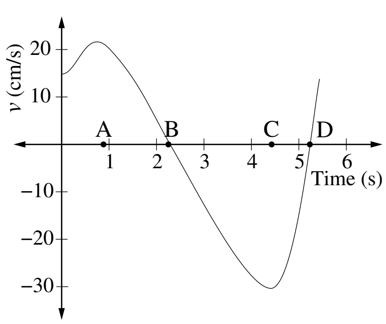
   - 0.090
   - 70.0
   - 0.72
   - 720
   - 0.63×10^4
   - 5.02
   - 0.00742
   - 0.720
   - 7210
   - 39.1×10^{14}

   A. five
   B. six
   C. seven
   D. none of the above

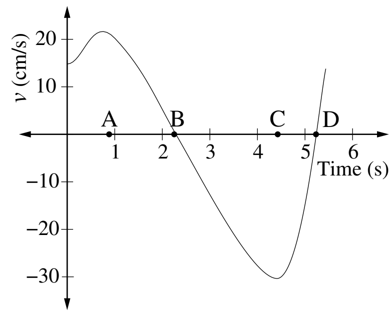
2. The below displays the vectors $\vec{\mathbf{p}}$ and $\vec{\mathbf{q}}$ in various orientations. The vectors always have the same length, only the orientation is changing. Circle the case in which $|\vec{\mathbf{q}} + \vec{\mathbf{p}}|$ is the largest.



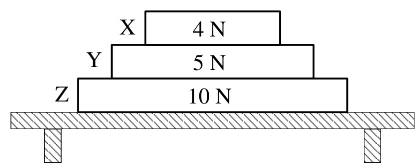
3. The below graph displays the velocity, v, of an object as a function of time. Mark the labeled time when the object has achieved its maximum x position. (Note: negative numbers are smaller than any positive number.)



4. The below graph displays the velocity, v, of an object as a function of time. Mark the labeled time when the particle has the maximum acceleration. (Note: negative numbers are smaller than any positive number.)



5. Three books (X, Y, and Z) rest on a table. The weight (i.e., mg) of each book is indicated. The net force on book Z is:



   A. zero
   B. 9 N
   C. 10 N
   D. 19 N

6. Rupert escapes from a dorm by sliding down rope. As he slides down the rope faster and faster, he becomes frightened and grabs harder on the rope, increasing the tension in the rope. As soon as the upward tension in the rope becomes equal to his weight…

   A. Rupert will stop
   B. Rupert will slow down
   C. the rope will break
   D. none of the above

7. Romeo throws a pebble at Juliet's window. It bounces off; no harm done. Bluto throws a brick at Olive Oyl's window. It crashes through breaking the window.

   A. The pebble's force on the window is less than the window's force on the pebble, so no harm is done.

   B. The brick's force on the window is greater than the window's force on the brick, so the window breaks.

   C. Both of the above.

   D. None of the above.

8. A crate rests in the middle of the floor in an otherwise empty van going west on I-94 at 70 mph. Suddenly a cute fawn jumps onto the road directly in front of the van; the driver hits the brakes and comes to a stop, missing the fawn. Throughout this process the crate remains at the same spot in the middle of the van's floor. During the braking. . .

   A. the net force on the crate points towards the front of the truck.

   B. the net force on the crate points towards the back of the truck.

   C. the net force on the crate is zero.

9. Rhonda throws a steel ball straight up. Consider the motion of the ball only after it has left her hand but before it touches the ground and assume that forces exerted by the air are negligible. For these conditions, the force(s) acting on the ball is (are):

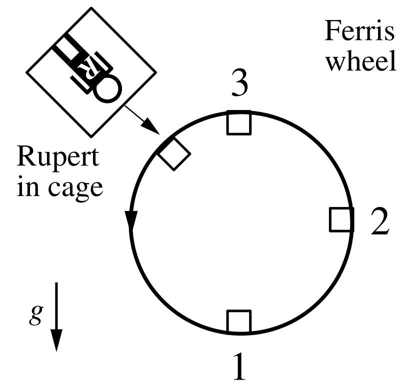
   A. a downward force of gravity along with a steadily decreasing upward force.

   B. a steadily decreasing upward force from the moment the ball leaves Rhonda's hand until it reaches its highest point; on the way down there is a steadily increasing downward force.

   C. an almost constant downward force of gravity along with an upward force that steadily decreases until the ball reaches its highest point, after which there is only the constant downward force of gravity.

   D. a constant downward force of gravity only.

10. A giant Ferris wheel having a diameter of 40 m, is fitted with a cage and platform on which Rupert stands. The wheel rotates rapidly at constant speed allowing Rupert to stand upright in the cage. Consider the magnitude of the net force on Rupert when he is at three locations (shown below as 1, 2, and 3) on the revolving Ferris wheel.



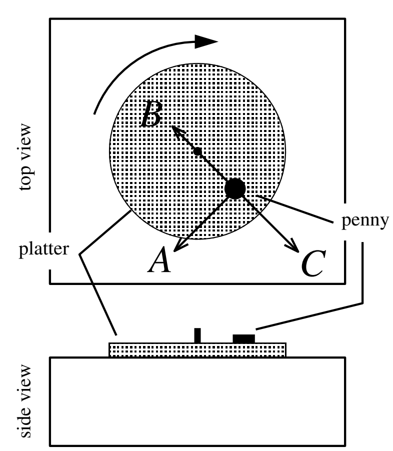
   A. The net force is largest at #1.

   B. The net force is largest at #2.

   C. The net force is largest at #3.

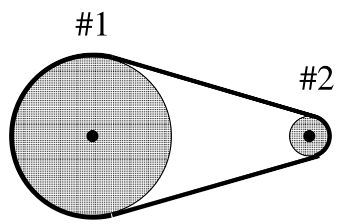
   D. None of the above: the net force has constant magnitude.

11. A penny is placed on the rotating platter of a turntable; it remains in place due to static friction. Circle the below letter that best describes the direction of this frictional force.



   D. none of the above

12. A belt drives (without slipping) a large radius pulley (#1) from a small radius pulley (#2) as shown below. Please compare the angular velocity of each pulley (ω_1, ω_2) and the speed at the edge of each pulley (v_1, v_2). Which combination of statements is correct?



A. $\omega_1 < \omega_2$, $v_1 > v_2$

B. $\omega_1 = \omega_2$, $v_1 > v_2$

C. $\omega_1 < \omega_2$, $v_1 = v_2$

D. $\omega_1 = \omega_2$, $v_1 = v_2$

The following questions are worth 12 pts each

Record your steps! (Grade based on method displayed not just numerical result)

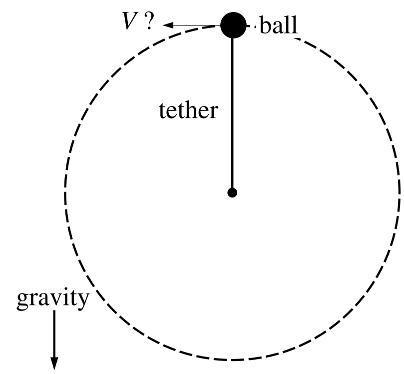
13. Consider a coordinate system in which the y direction points due north and the x direction points due east. The following vectors are given:

$$\begin{aligned} \vec{\mathbf{a}} &= 8 \text{ km } 30^\circ \text{ east of north} \\ \vec{\mathbf{b}} &= 4 \text{ km } 10^\circ \text{ north of due west} \\ \vec{\mathbf{c}} &= 2 \text{ km due north} \end{aligned}$$

Sketch (approximately) each of the above vectors and display how all four arrows can be arranged to find $\vec{\mathbf{d}} = \vec{\mathbf{a}} + \vec{\mathbf{b}} - \vec{\mathbf{c}}$ graphically. Resolve the vectors into (x, y) components and calculate $\vec{\mathbf{a}} + \vec{\mathbf{b}} - \vec{\mathbf{c}}$ using the component forms. Express the resultant vector, $\vec{\mathbf{d}}$, in magnitude and direction form. (Display on your drawing the angle you are reporting.)

14. A long straight road in North Dakota stretches for 100 miles in a straight line with occasional stop signs. Starting from rest at a stop sign, you accelerate at 1 m/s^2 for 20 seconds, maintain your speed for the next 60 seconds, and then hit the brakes (de)accelerating at -4 m/s^2 until you are again stopped at a stop sign. Sketch a graph of your velocity vs. time. What distance separates the two stop signs? Convert your answer to miles where 1 mile = 1609 m.

15. A ball (of mass 0.1 kg) is attached to a tether and swung around in a vertical circle of radius 1 m. When the ball is at the top of the circle (as shown) the tension in the tether is 0.62 N. Draw a free body diagram showing/naming all the forces acting on the ball and the direction of any resulting acceleration. Find the speed of the ball at that time.



16. A large slab ($M = 10$ kg) sits on frictionless surface. A block ($m = 1$ kg) rests on top of the slab. The surface between the slab and the block has a coefficient of static friction of $\mu_s = 0.4$ and a coefficient of kinetic friction $\mu_k = 0.3$. The slab is pulled with a horizontal force T. If T is sufficiently small the block+slab will move together as one object; if T is larger, there will be slippage and the slab will accelerate faster than the block (and the block will eventually fall off the back of the slab).

   A. Draw free body diagrams for each mass separately. Show and name all forces acting each mass. Show the direction of the acceleration (if there is any).

   B. *For each mass separately* and for both the x and y directions, write down the equations that follow from Newton's second law ($F_{\text{net}} = ma$).

   C. If $T = 50$ N, there will be slippage. Find the acceleration of each mass in this case.