Instructions:

Do not open this examination until the proctor tells you to begin.

1. When the proctor tells you to begin, **write your full name at the top of every page.** This is essential since this exam booklet will be separated for grading.

2. Do your work for each problem on the page for that problem. You might find it convenient to either do your scratch work on the back of the page before starting to write out your answer or to continue your answer on the back. **If part of your answer is on the back, be sure to check the box on the bottom of the page so the grader knows to look on the back!**

3. On all the problems except the multiple choice questions in problem 1 or where it says **not to explain,** your answers will be evaluated at least in part on how you got them. More than half the credit of the problem may be given for the explanation. **YOU MAY EARN LITTLE OR NO CREDIT FOR YOUR ANSWERS IF YOU DO NOT SHOW HOW YOU GOT THEM.** Partial credit will be granted for correct steps shown, even if the final answer is wrong. Explanations don’t need to be long, but they need to show what physics you are using and assumptions you are making.

4. Write clearly and logically so we can understand what you are doing and can give you as much partial credit as you deserve. We cannot give credit for what you are thinking — only for what you show on your paper.

5. If you try one approach and then decide on another, cross out the one you have decided is wrong. If your paper contains both correct and incorrect approaches the grader will not choose between the two. You will not receive any credit when contradictory statements are present, even if one is correct.

6. All calculations should be done to the appropriate number of significant figures.

7. At the end of the exam, write and sign the honor pledge in the space below (“I pledge on my honor that I have not given or received any unauthorized assistance on this exam.”):

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*** Good Luck ***
1. (30 points) The apparatus shown in the figure below uses a spring to launch a small block along a track. A latch holds the block of mass $M$ in place against the compressed spring (spring constant $k$) as shown. When the ring is raised the block is launched along the track. The parts of the track from A to B and from C to D can be considered frictionless for this problem. The part from B to C has significant friction (coefficient of sliding friction, $\mu$).

When the block is launched, it gets through the frictional part, rises up the ramp to the point D, a height $h$ above the straight part of the ramp. It then slides back down. On its return, it gets to the point B and stops.

For the items below choose the symbol that best completes the sentence and put it in the box on the right of the question: Use one of the following symbols: greater than ($>$); less than ($<$); equals ($=$), positive (+), negative (-), zero (0). If none complete the sentence correctly, put N. (6 each)

A. The potential energy stored in the spring just before the mass is released is ____ the kinetic energy of the mass as it is reaches the point B.

B. The potential energy stored in the spring just before the mass is released is ____ the gravitational potential energy of the mass as it is reaches the point D.
(Take the zero of gravitational PE at the level of the straight part of the track.)

C. In the overall motion, the magnitude of the total work done by the frictional force is ____ the magnitude of the total work done by the spring force.

D. The total work done by the gravitational force throughout the whole motion is ____

E. The total work done by the friction force throughout the whole motion is ____. 

If you need more space, continue on the back and check here.
2. (20 points) In class we considered a demonstration in which we let a ball (B) – either a superball (SB) and a clay ball (CB) (of equal masses) – swing down to hit a wooden block (WB) as shown in the figure at the right.

The balls each have a mass of 50 g, and the block has a mass of 1000 g. When the balls are dropped, they fall a distance of 40 cm before hitting the block in the center. For each of the items below, show your reasoning in the space under the problem (or on the back) and put your answer in the box at the right. For this problem, take $g = 10 \text{ N/kg}$.

(a) How fast are the balls traveling just before they are about to hit the block? (6 pts)

$$v_B^i =$$

(b) When the clay ball hits the block, it does not stick, but deforms and comes to almost a dead stop but does not stick to the block. During its collision with the block, other forces acting on the ball and block almost cancel. How fast is the block traveling just after the ball has hit it? (6 pts)

$$v_{WB}^f =$$

(c) When the superball hits the block, it bounces back, traveling with 90% of its original speed. During its collision with the block, other forces acting on the ball and block almost cancel. How fast is the block traveling just after the ball has hit it? (8 pts)

$$v_{WB}^f =$$

If you need more space, continue on the back and check here.
3. (15 points) Your moving car contains a lot of energy as kinetic energy – energy of motion. If your car is not a hybrid, when you stop by stepping on the brake, your energy of motion is transformed by friction (in the brakes, against the road) into thermal energy. It can’t be re-used. Estimate how many gallons of gasoline you could save each time you stopped your car from a speed of 100 km/hr if you could store that energy somehow and re-use it. [Hint: One gallon of gasoline contains about 1.2 x 10^9 Joules of energy. (1 Joule = 1 kg-m^2/s^2).] Be sure to clearly state your assumptions and how you came to the numbers you estimated, since grading on this problem will be mostly based on your reasoning, not on your answer.
4. (10 points) Kevin, Joe, and Nick are studying for their physics exam, but they are very confused about momentum conservation. A reading question in their text asks whether the momentum of a ball thrown upward is conserved after it leaves the hand. Kevin says, “The answer is yes since momentum is always conserved.” Joe says, “It can’t be. It slows down and speeds up.” Nick says, “there’s no other object involved after it’s released so it must be conserved.” Do you agree with any of them, or are they all wrong? Explain whether momentum is conserved for the ball and explain how you can tell in general whether the momentum of a system of objects is conserved. \textit{Note: This is an essay question. Your answer will be judged not solely on its correctness, but for its depth, coherence, and clarity.}
5. (25 points) In the figure at the right is shown a simulation of a skateboarder sliding along a curved track. The dotted line at the bottom of the track shows where we have taken the zero of the gravitational potential energy. Seven points along the track are marked with small circles (labeled A – G). The skateboarder starts at rest at the point labeled A. He then starts rolling down the track. For the purposes of this exam, you may ignore friction and the rolling effects of the (small) wheels.

A) In the figure at the right is shown a bar graph representing the division of energies at one of the labeled points. Which point do you think it is? Put your choice in the box at the left and justify your answer in the space below. (5 pts)

B) In the figure at the right is shown a plot of the skateboarder’s various energies as a function of time. Where is he on the track at $t = 0\, \text{s}$, $2.9\, \text{s}$, $5.3\, \text{s}$, and $6.9\, \text{s}$? (These times are marked by arrows below the graph.) Put your answers in the box and justify them in the space below. (12 pts)

C) The skateboarder and his skateboard together have a mass of 75 kg. If he is traveling at 2 m/s when he is at point C, 3.3 meters about the lowest point on the track, how high is point A above the lowest point on the track? (8 pts)

If you need more space, continue on the back and check here.