PLEASE DO NOT LOOK AT THE CONTENTS OF THIS EXAM, OTHER THAN THIS COVER PAGE, UNTIL TOLD TO DO SO.

- Please write your name and student ID number, and sign the pledge (below), on this cover sheet. Unsigned exams will not be graded.
- On the bubble sheet, as your identifying number, please fill in your “exam number” from the upper right-hand corner of the exam’s cover sheet.
- This midterm is closed book, closed notes, and silent.
- You may not consult any books, notes, computers, or calculators during the exam.
- You may not use head phones, microphones, or cellular phones during the exam.
- You may not have any additional paper on your desk during the exam.
- Once the exam has begun, you may not leave the exam room without permission.
- You may not take this exam out of this room.

- On multiple choice questions, please mark the correct answer for each question on the bubble sheet.
- To minimize the possibility of mistakes later, you should also circle your choice on the exam booklet. There will be one choice and one choice only for each multiple choice question.
- On short answer questions (# 19 – #23) please write a brief answer contained within the box that is provided.
- Multiple choice questions are worth one point.
- Short answer questions are worth two points.

Name: **Solutions** - please note that the order of the multiple choice questions appearing in these solutions may be different than the order in your exam. The questions, however, are the same.

Student ID#:

On my honor as a student of the University of Virginia I have neither given nor received aid on this exam. I have read all of the exam rules stated above, and have completed this exam honestly, according to those rules. I will report, to Professor Cates or an Honor Advisor, any act of dishonorable conduct and/or violation of the exam rules that I have witnessed during this exam.

Signed:

Date:
1. Suppose that you try bowling two different bowling balls, one with twice the mass of the other. If you push on them with equal forces, how will the lighter one respond in comparison to the heavier one:
   a. It will accelerate at four times the rate of the heavier one.
   b. It will accelerate at the same rate as the heavier one.
   c. It will accelerate at half the rate of the heavier one.
   d. It will accelerate at twice the rate of the heavier one.

2. Out in deep space, far from any celestial object that exerts significant gravity, would an astronaut weigh anything? Would she have any mass?
   a. Her mass and weight would be the same as on the Earth, she simply wouldn’t accelerate.
   b. Her weight would be the same, but she would have essentially no mass.
   c. Her mass would be the same, but she would have essentially no weight.
   d. Both her mass and her weight would be vanishingly small.

3. You are planning to construct a bungee-jumping amusement at the local shopping center. You want your customers to have a 4-second free-fall experience. How far will they fall in 4 seconds? You may assume that the acceleration due to gravity is 10 meters/second².
   a. 160 meters
   b. 80 meters
   c. 40 meters
   d. 20 meters

4. When you throw a ball horizontally, you are not pushing against gravity. Are you doing any work on the baseball?
   a. No, not if you truly throw it on a perfectly horizontal trajectory.
   b. Yes, and the amount of work depends on how fast you throw the ball, and on the ball’s mass.
   c. Yes, and the amount of work depends on how fast you throw the ball, but not on the ball’s mass.
   d. Yes, but regardless of the ball’s mass and final speed, the work you do depends solely on the distance over which you apply force to the baseball.

5. Which of the following types of electric motors will produce standard alternating current if you turn the shaft?
   a. A universal motor.
   b. A brushed DC motor.
   c. An AC synchronous motor.
   d. An induction motor.
6. Some hammers have a special claw designed to remove nails from wood. When you slide the claw under the nail’s head and rotate the hammer by pulling on its handle, the claw pulls out the nail. The hammer’s head contacts the wood to form a pivot that’s about 10 times closer to the nail than to the end of the handle. If you exert a force of 100 N on the hammer’s handle, how much force is the nail exerting on the hammer’s claw?

(a) You can exert a force of 1000N on the nail, but only if you are careful to pull on the hammer’s handle in the correct direction.
(b) Despite providing a less awkward way of pulling out the nail, you are still only exerting a force of 100 N on the nail.
(c) If the force you exert on the handle is 100 N, the force you exert on the nail will always be 1000 N.
(d) 10 N.

7. Antilock brakes keep an automobile’s wheels from locking and skidding during a sudden stop. Why do anti-lock brakes help a car stop faster?

(a) If the tires do not skid, the force of the road on the car will be due to sliding frictional forces, which are always stronger than static frictional forces.
(b) If the tires do not skid, the force of the road on the car will be due to static frictional forces, which will always be larger than sliding frictional forces.
(c) If the tires skid, the force of the road on the car will be due to sliding frictional forces, and the tires may be damaged due to excessive heating.
(d) If the tires do not skid, the force of the road on the car will be due to static frictional forces, and the maximum static frictional force is always larger than sliding frictional forces.

8. If you plug an electric hairdryer into the wall outlet and turn it on, current will begin to flow through wires inside the wall. Some of the electric power carried by that current will be wasted as heat in those wires. If you plug a second identical hairdryer into the same outlet and turn it on, the amount of power wasted in the wires will

(a) remain almost the same because the voltage in the wires will change very little.
(b) increase by a factor of 2.
(c) increase by a factor of 4.
(d) remain almost the same because the current in the wires will change very little.

9. A thick wire connects the lightning rod on the courthouse steeple to the ground and in normal good weather ensures that the rod is electrically neutral. This day, however, it is stormy and a negatively charged cloud floats overhead.

(a) The rod becomes positively charged.
(b) The rod will remain electrically neutral unless struck by lightening.
(c) The rod becomes negatively charged.
(d) The charge depends on whether the cloud is approaching or moving away.
10. Which of the following electrical components is used to store energy?
   a. Capacitors.
   b. Diodes.
   c. Transformers.
   d. Resistors.

11. Nuclear physicists use Van de Graaff generators to accelerate atoms to high energies
    in order to study nuclear reactions. A carbon atom that is missing one electron moves
    from a region where the voltage is +10,000 volts toward a target that sits at 0 volts. A
    second carbon atom that is missing three electrons moves from the same region where
    the voltage is +10,000 volts toward the same target which is at 0 volts. How much
    kinetic energy will the second carbon atom have when it hits the target compared to
    the first carbon atom?
   a. The same.
   b. Twice as much.
   c. Three times as much.
   d. Nine times as much.

12. When you pull a child back on a playground swing and let go, which way does that
    child accelerate?
   a. Forwards along a line tangential to the arc traced out by the swing.
   b. Forwards along the horizontal direction
   c. Downwards along the vertical direction.
   d. Upwards along the vertical direction.

13. Your friend has a gold ring that forms a continuous loop around her finger. If you
    hold the north pole of a permanent magnet near that ring and then suddenly pull the
    magnet away, an electric current will flow around the ring because the
   a. magnet’s north pole attracts positive charge and pulls that charge around the
      ring.
   b. magnet’s north pole repels positive charge and pushes that charge around the
      ring.
   c. decreasing magnetic field will produce an electric field in the ring and this electric
      field will push charge around it.
   d. magnet’s electric field decreases as you pull it away from the ring and this change
      will cause current to flow around the ring.

14. Your professor in How Things Work is spinning around on a rotatable chair with his
    arms extended. He is holding small weights in each hand. At some point he pulls in
    his arms, tucking them, his hands, and the weights close in toward his body. As he is
    in the process of doing this, which of the following quantities does not change?
   a. His rotational mass.
   b. His angular velocity.
   c. His angular acceleration.
   d. His angular momentum.
15. To produce the high voltages it needs for its tube, a neon sign uses a transformer. AC current from the power company flows through that transformer’s primary coil and a separate current flows through the transformer’s secondary coil. To obtain a large voltage rise across its secondary coil, the transformer is built with
   a. many more turns in the primary coil than in the secondary coil.
   b. thicker wires in the secondary coil than in the primary coil.
   c. many more turns in the secondary coil than in the primary coil.
   d. thinner wires in the secondary coil than in the primary coil.

16. A xerographic copier makes sure that the two sides of its photoconductor are oppositely charged before it exposes that photoconductor to light from the original document. If the photoconductor were not electrically charged before the exposure to light from the document,
   a. charge would flow through it backwards during the exposure and its two sides would end up charged the wrong way.
   b. no charge would flow through it during the exposure.
   c. only the regions that were not exposed to light would become charged and the copier would produce a negative image on the paper.
   d. charge would flow through it back and forth, as an AC current, and it would overheat.

17. The principal advantage of sending electric power across country on very high voltage transmission lines is that
   a. They carry less energy per charge than low voltage transmission lines.
   b. The electric power lost in the wires is greatly reduced.
   c. These transmission lines are less likely to get in the way than low voltage transmission lines which are much closer to the ground.
   d. They carry much more current than low voltage transmission lines.

18. A power adaptor can be represented schematically by the figure shown at right. Which of the plots below best represents the current versus time passing through the radio in the schematic?

(a)  
(b)  
(c)  
(d)
19. You are powering a light bulb with a 12 volt battery as shown. The light bulb has a resistance of 3 Ohms. The wires leading to the light bulb are very long, and each wire has a resistance of 1.5 Ohms.

a. How much current flows in the circuit?

Total resistance \( R_T = 3 \text{ Ohms} + 1.5 \text{ Ohms} + 1.5 \text{ Ohms} = 6 \text{ Ohms} \)

Ohm's law is \( V = I R \), so we know that here \( I = V/R_T = 12 \text{ Volts}/6 \text{ Ohms} \)

\[ = 2 \text{ Amperes} \]

b. How much power is being consumed by the light bulb itself? How much power is being wasted in the long wires?

Power consumed by any resistive circuit element is given by the formula \( P = I^2 R_T \).

Power consumed by light bulb = \( (2 \text{ Amps})^2 (3 \text{ Ohms}) = 12 \text{ Watts} \)

Power consumed by wires = \( (2 \text{ Amps})^2 (1.5 \text{ Ohms} + 1.5 \text{ Ohms}) \)

\[ = (2 \text{ Amps})^2 (3.0 \text{ Ohms}) = 12 \text{ Watts} \]

Note that a good check of these results is to compute the power produced by the battery, given by \( P = I V = (2 \text{ Amps}) (12 \text{ Volts}) = 24 \text{ Watts} \), which is the sum of 12 W and 12 W the power consumed by the bulb and the wires individually.

20. You are towing your friend’s car up a long steep hill at a constant speed. The height of the hill is 50 meters. The road leading to the top of the hill is straight, at a constant incline, and 250 meters in length. The weight of your friend’s car is 10,000 Newtons. What is the size of the force that you must exert on your friends car?

The force needed to pull an object up a (frictionless) ramp is given by the weight of the object times the ratio of the height to the length of the ramp.

\[
\text{Force needed} = \left( \frac{(50 \text{ meters})}{(250 \text{ meters})} \right) 10,000 \text{ Newtons} \\
= (1/5) 10,000 \text{ Newtons} \\
= 2,000 \text{ Newtons}
\]
21. You can avoid the shock of static electricity by holding out a sharp needle as you reach for a metal doorknob or wall. How does that needle protect you from static electricity?

The needle functions like a lightning rod. If you are carrying a net charge, there will be a concentration of charge at the end of the needle and a strong electric field which will initiate a corona discharge. The corona discharge will both limit the total charge you can accumulate in the first place, as well as ensuring that as you approach the doorknob, you will dump your charge gradually.

Note: the answer given above is certainly more complete and detailed than I would necessarily expect you to give on the exam.

22. If you send direct current through the primary coil of a transformer, no power will be transferred to the secondary circuit. Explain why this is the case.

Transformers depend on AC current to function. This is because it is the changing magnetic fields generated by the primary coil (which are caused by the alternating current), that induce a voltage in the secondary coil. If there are no changing magnetic fields, you cannot generate voltages in the secondary coil.

23. Explain the role of diodes in an AC power adapter.

A diode functions as a one way valve for current. By using a collection of diodes, a power adapter ensures that one output of the adapter is always positive and the other output is always negative.