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All questions on the test are multiple choice. Choose only one answer for each question, and fill it out on your bubblesheet (scantron). Each question is worth 4 points.

1. In a vacuum, a metal sphere with a positive electric charge Q briefly touches a smaller, electrically neutral (uncharged) sphere. Afterward, the two spheres repel each other. After the spheres touch, the charge of the ***larger*** sphere is

   A. greater than Q

   B. equal to Q

   C. equal to $-Q$

   D. less than Q but greater than zero

   E. zero

2. A point charge of magnitude $2Q$ exerts an electrostatic force of magnitude F on a point charge of magnitude Q that is a distance R away. What is the magnitude of the force that the $2Q$ point charge exerts on a point charge of magnitude $3Q$ that is a distance $R/5$ away?

   A. $15F$

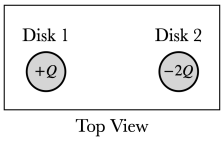
   B. $30F$

   C. $37.5F$

   D. $75F$

   E. $150F$

3. Disks 1 and 2 have the same mass, and net electric charge $+Q$ and $-2Q$ respectively, as shown at right. The disks are released from rest on a frictionless horizontal surface. At a later time, but before the disks collide, how do their speeds compare? Let v_1 refer to the speed of disk 1, and v_2 refer to the speed of disk 2.



   A. $v_1 < v_2$

   B. $v_1 = v_2$

   C. $v_1 > v_2$

   D. We don't have enough information to know how the speeds compare.

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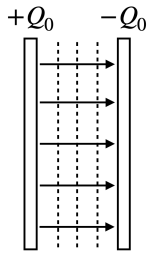
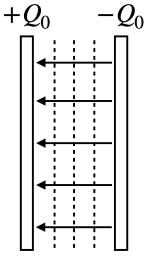
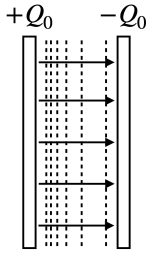
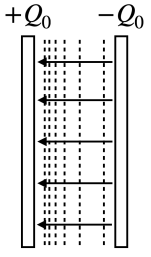
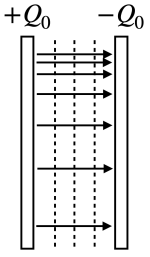
4. Which of the following best represents the electric field and equipotential lines between two oppositely charged parallel plates?

A. 

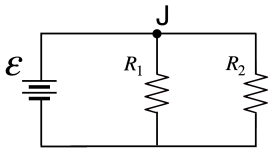
B. 

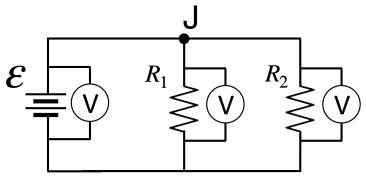
C. 

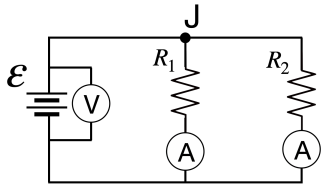
D. 

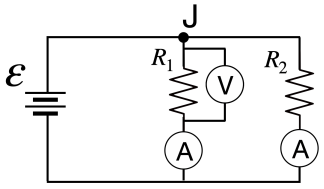
E. 

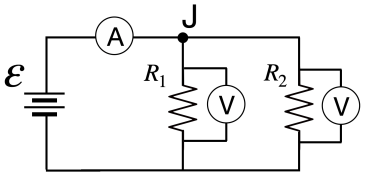
5. The circuit shown to the right contains a battery of potential difference $\mathcal{E}$ and resistors of known resistances R_1 and R_2. A student is asked to take measurements of the circuit to verify Kirchhoff's junction rule through the junction J. Multiple voltmeters and ammeters are available for use. Which of the following combinations of meters could be used?



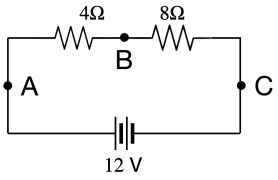
A. 

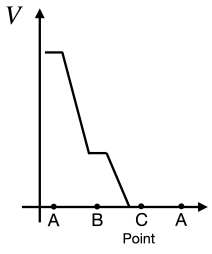
B. 

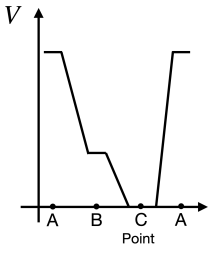
C. 

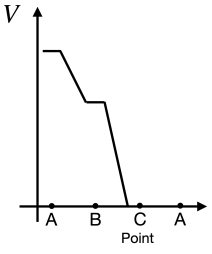
D. 

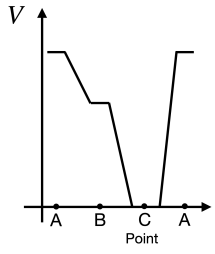
6. A 12 V battery is connected in series with a 4 Ω and an 8 Ω resistor, as shown. The wires have negligible resistance. A voltmeter is used with one probe touching the negative terminal of the battery and the second probe moving around the circuit. Which of the following graphs best represents the potential difference measured by the voltmeter when the second probe starts at point A and follows a counter-clockwise path around the circuit all the way back to A?



A. 

B. 

C. 

D. 

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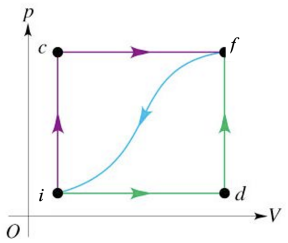
7. When a system is taken from an initial to a final state along path i-c-f, there is 95 J of heating, and the system does 30 J of work. How much heating occurs along the path i-d-f if the work done is 10 J?



A. 20 J

B. 95 J

C. 115 J

D. 125 J

E. 75 J

8. It is known that a plastic block changes temperature by 5 °C when 1500 J of heat are transferred to/from it. This block, starting at room temperature (20 °C), is placed into an insulated jar that contains 0.5 kg of water at a temperature of 100 °C. Which of the following choices is closest to the final temperature?

A. 30 °C

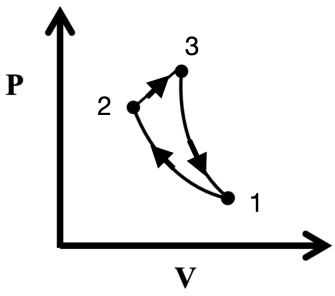
B. 40 °C

C. 60 °C

D. 80 °C

E. 90 °C

9. A cyclic thermodynamic process is shown. What are the signs of Q, the heat added to the system, W, the work on the system, and ΔE_{th}, the change in internal energy of the system, in one complete cycle?



	Q	W	ΔE_{th}
A.	−	0	−
B.	−	+	+
C.	+	−	+
D.	−	+	0
E.	+	−	0

10. A gas process is described by the 1st law of thermodynamics ($\Delta E_{th} = Q + W$) as follows:

$$-2P_0V_0 = Q - 3P_0V_0$$

where P_0 and V_0 represent a particular value of pressure and volume. Which of the following statements could be true?

A. The gas expands and is cooled.

B. The gas expands and is heated.

C. The gas is condensed and is cooled.

D. The gas is condensed and is heated.

E. The gas is cooled at a constant volume.

11. In the four cases below T_{low} refers to the same temperature in each case, and T_{high} refers to the same higher temperature in each case. Rank the following quantities from LARGEST to SMALLEST:

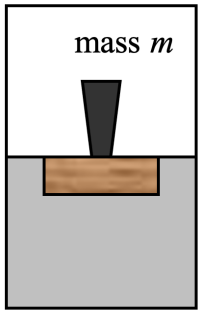
    1. The internal energy change of one mole of an ideal gas in an isothermal process at T_{high}
    2. The work done on one mole of an ideal gas in an adiabatic process going from temperature T_{low} to a higher temperature T_{high}
    3. Heating of one mole of an ideal gas during an isovolumetric process going from temperature T_{low} to a higher temperature T_{high}
    4. Heating of one mole of an ideal gas in an isobaric process going from temperature T_{low} to a higher temperature T_{high}

    A. $3 > 2 = 1 > 4$
    B. $2 = 3 > 4 > 1$
    C. $1 = 2 > 3 > 4$
    D. $4 > 2 = 3 > 1$
    E. $2 > 3 = 1 > 4$

12. Two moles of an ideal gas are compressed isothermally. During the compression, 328 J of work is done on the gas and no work is done by the gas. Which of the following statements is TRUE?

    A. More than 328 J of energy must leave the gas through cooling.
    B. Exactly 328 J of energy leaves the gas through cooling.
    C. The compression is isothermal so there is no heating or cooling.
    D. Exactly 328 J of energy enters the gas through heating.
    E. More than 328 J of energy must enter the gas through heating.

13. A block of wood of length $L = 0.21$ m, width $w = 0.16$ m, and height $h = 5.9 \times 10^{-2}$ m is just barely immersed in water by placing a mass m on top of the block. The density of the wood is $\rho_{wood} = 390$ kg/m^3 and the density of water is $\rho_{water} = 1000$ kg/m^3. The value of m is closest to



    A. 0.36 kg
    B. 0.58 kg
    C. 0.72 kg
    D. 1.2 kg
    E. 1.6 kg

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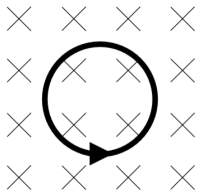
14. A charged particle moves in a circle at a steady speed due to a uniform magnetic field, as shown. Consider a particle with the same mass moving at the same speed in the same magnetic field, except that the charge of the particle is twice as large. How would the radius of the path of this particle compare to the one shown?



A. The radius would be twice as large.

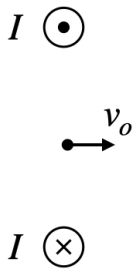
B. The radius would be half as large.

C. The radius would not change.

D. The radius would be smaller, but not by half.

E. The radius would be larger, but not twice as large.

15. A negative particle moves between two current carrying wires as shown. In which direction is the force on the particle?



A. Upwards

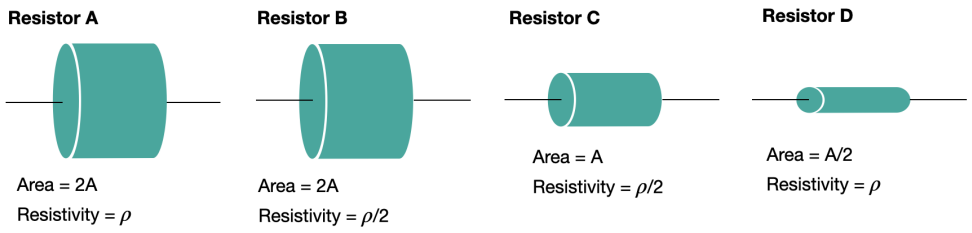
B. Downwards

C. Out of the page

D. Into the page

E. The force is zero

16. Four resistors, shown below, are all connected to identical batteries. They have the same length, but different cross-sectional areas and are made of different materials with different resistivities. How does the resistance of the different resistors compare?



A. $R_B < R_C = R_A < R_D$

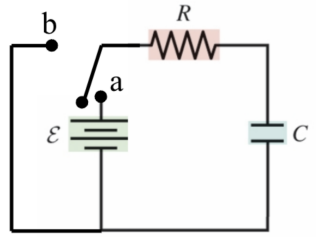
B. $R_C = R_B < R_A < R_D$

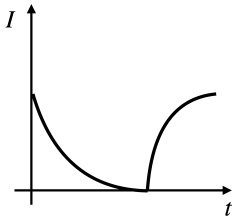
C. $R_C = R_D > R_B > R_A$

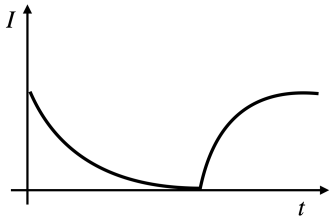
D. $R_C < R_B < R_A = R_D$

E. $R_D < R_B < R_A = R_C$

17. The amlunt of current that passes through the resistor in an RC circuit is measured as the capacitor is charged (with the switch in position a) and then discharged (with the switch in position b). The amount of current as a function of time is shown below, at the left. One change is made to the circuit, and then the current is measured again. The amount of current as a function of time for this second circuit is shown below, at the right.







Which of the following changes could have resulted in the new current function shown?

A. The resistor was exchanged with one that is twice as long, and is otherwise the same.

B. The capacitor was exchanged with one that has half the area, and is otherwise the same.

C. A second battery was added in series.

D. The resistor was changed to one with resistance $R/2$ and the capacitor was changed to one with capacitance $2C$.

E. The direction of the battery was reversed.

18. A cyclist is biking up a mountain, and gains 1200 J of gravitational potential energy. During their journey, 3200 J of their usable chemical energy contributes to both increasing their kinetic energy by 800 J and to helping them continue to cycle. Which of the following most closely matches the cyclist's change in thermal energy?

A. 700 J

B. 1200 J

C. 1700 J

D. 2000 J

E. 2700 J

19. Two blocks, A and B, are added to a tub of water. It is observed that Block A floats and Block B sinks. Which of the following ***must be true*** about how the blocks compare?

A. The mass of Block A is less than the mass of Block B.

B. The volume of Block A is less than the volume of Block B.

C. The volume of Block A is greater than the volume of Block B.

D. The density of Block A is less than the density of Block B.

E. The weight of Block A is less than the weight of Block B.

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20. Three moles of ideal gas are sealed inside a cylinder that has a movable piston. With the piston fixed in place, the pressure, volume and temperature of the gas are measured. Then the volume is halved while the temperature is held constant. The average speed of the gas molecules

A. is half as big as it was.

B. is one-quarter as big as it was.

C. doubles.

D. is unchanged.

E. quadruples.

21. 

Consider the portion of a flow tube shown in the figure. Point 1 and point 2 are at the same height and point 1 is open to the air (point 2 is not open to the air and is connected to more pipe which is not shown here). The water has a speed of v_1 at point 1 and moves steadily toward point 2 where it has speed v_2. The cross section of the flow tube at point 1 is greater than that at point 2. The density of water ρ_w =1000 kg/m^3. Which of the following is closest to the pressure P_2 at point 2 if $v_1 = 1.0$ m/s, $v_2 = 5.0$ m/s, $P_1 = 10^5$ Pa?

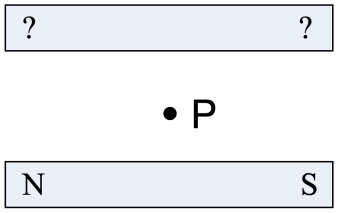
A. 9.8×10^4 Pa

B. 9.2×10^4 Pa

C. 1.0×10^5 Pa

D. 1.1×10^5 Pa

E. 8.8×10^4 Pa

22. 

Consider the magnets arranged as shown, where the poles and strength of the magnet on top are unknown. If the magnetic field points to the right at point P, which of the following could be true about the top magnet?

A. The north pole is on the right and the magnet is stronger than the magnet on the bottom.

B. The north pole is on the right and the magnet is just as strong as the magnet on the bottom.

C. The north pole is on the left and the magnet is just as strong as the magnet on the bottom.

D. We do not have enough information to know.

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23. For a particular cyclic engine, $T_{hot} = 750$ K, $T_{cold} = 250$ K, $Q_{hot} = 1000$ J, and $Q_{cold} = 700$ J . Determine the real efficiency of this engine.

A. 0.30

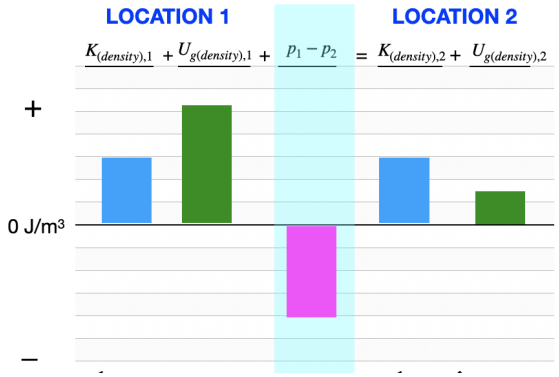
B. 0.80

C. 0.75

D. 0.67

E. 0.53

24. Water travels through a pipe. Let the cross-sectional area be represented by A and the elevation by y. Which of the following corresponds to the Bernoulli energy bar chart shown?



A. $A_1 > A_2$ and $y_1 > y_2$

B. $A_1 < A_2$ and $y_1 > y_2$

C. $A_1 > A_2$ and $y_1 < y_2$

D. $A_1 < A_2$ and $y_1 < y_2$

E. $A_1 = A_2$ and $y_1 > y_2$

25. Your heart pumps blood at a flow rate of about 80 cm^3/s. The blood flows through approximately 9×10^9 capillaries, each of radius 4×10^{-4} cm and 0.1 cm long. Determine the viscous friction pressure drop across a capillary, assuming a blood viscosity of 4×10^{-3} $N{\cdot}s/m^2$. **[Sections A and C may not have gotten to this material! We know that, and please don't stress about being able to do this problem for the final.]**

A. 204 Pa

B. 509 Pa

C. 3.18×10^4 Pa

D. 3.18×10^6 Pa

E. 3.18×10^{12} Pa