Linnemann,

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Keep this exam **CLOSED** until advised by the instructor.

Fill out the bubble sheet: last name, first initial, student number, section number. Leave the code area empty.

120 minute long closed book exam.

Four 8.5 by 11 handwritten help sheets are allowed.

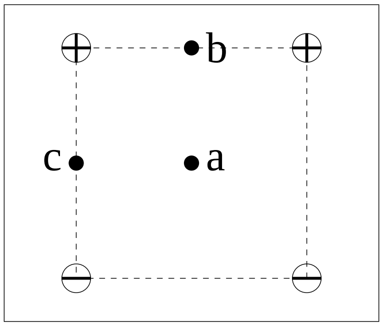
When done, hand in your **bubble sheet** and your **exam**. Keep your help sheets.

Thank you and good luck!

Possibly useful constants:

- $k_e = 8.99 \times 10^9$ Nm^2/C^2
- $\epsilon_0 = 8.85 \times 10^{-12}$ As/(Vm)
- $\mu_0 = 4\pi \times 10^{-7}$ Vs/(Am)
- $c = 3.00 \times 10^8$ m/s
- $e = 1.60 \times 10^{-19}$ C
- $m_e = 9.11 \times 10^{-31}$ kg
- $m_e c^2 = 0.511$ MeV
- $h = 6.63 \times 10^{-34}$ Js
- $h = 4.14 \times 10^{-15}$ eVs
- $hc = 1240$ eVnm
- Wien's constant $= 2.898 \times 10^{-3}$ Km
- 1 eV $= 1.60 \times 10^{-19}$ J

Four point charges equal in magnitude are arranged at the corners of a square as shown in the figure.



6 pt What is the direction of the electric field at point **a**?

1. **A**◯ The electric field is zero at this point.
B◯ To the left.
C◯ Down (to the bottom of the page).
D◯ To the right.
E◯ Up (to the top of the page).

6 pt What is the direction of the electric field at point **b**?

2. **A**◯ Down (to the bottom of the page).
B◯ To the right.
C◯ To the left.
D◯ Up (to the top of the page).
E◯ The electric field is zero at this point.

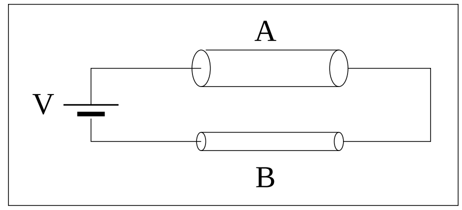
6 pt Select the only true statement about the electric potential at points **a**, **b** and **c**.

3. **A**◯ The electric potential equals zero at points **a** and **b** but not at **c**.
B◯ The electric potential equals zero at points **a** and **c** but not at **b**.
C◯ The electric potential equals zero at none of these points.
D◯ The electric potential equals zero at points **a**, **b** and **c**.
E◯ The electric potential equals zero at point **a** but not at **b** or **c**.

6 pt A uniform electric field of magnitude 233 V/m is directed in the negative y direction. A +11.6 μC charge moves from the origin to the point (x, y) = (20.4cm, 54.4 cm). What was the change in the potential energy of this charge?
(in J*)*

4. **A**◯ 1.07×10^{-3} **B**◯ 1.26×10^{-3} **C**◯ 1.47×10^{-3}
D◯ 1.72×10^{-3} **E**◯ 2.01×10^{-3} **F**◯ 2.35×10^{-3}
G◯ 2.76×10^{-3} **H**◯ 3.22×10^{-3}

6 pt The picture shows a battery connected to two cylindrical wires in series. Both wires are made out of the same material and are of the same length, but the diameter of wire **A** is twice the diameter of wire **B**.



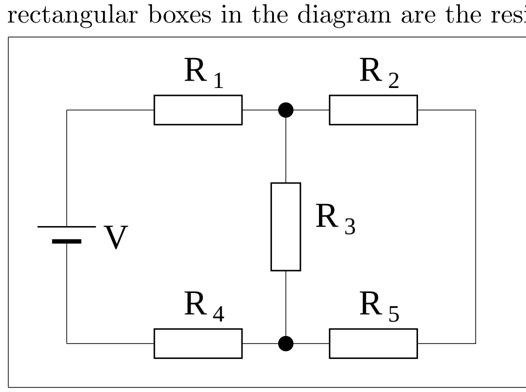
Choose the correct answer.

5. **A**◯ The resistance of wire B is twice as large as the resistance of wire A.
B◯ The resistance of wire B is four times as large as the resistance of wire A.
C◯ The resistance of wire B is equal to the resistance of wire A.
D◯ The resistance of wire B is one quarter as large as the resistance of wire A.
E◯ The resistance of wire B is half as large as the resistance of wire A.

6 pt Choose the correct answer.

6. **A**◯ The voltage drop across wire B is twice as large as the voltage drop across wire A.
B◯ The voltage drop across wire B is half as large as the voltage drop across wire A.
C◯ The voltage drop across wire B is four times as large as the voltage drop across wire A.
D◯ The voltage drop across wire B is equal to the voltage drop across wire A.
E◯ The voltage drop across wire B is one quarter as large as the voltage drop across wire A.

Consider the electric circuit shown in the figure. Assume that V = 22.0 V, $R_1 = R_2 = R_3 = R_4 = R_5 = 4.00\ \Omega$. (The rectangular boxes in the diagram are the resistors.)



6 pt What is the equivalent resistance of the circuit?
(in `ohm`*)*

7.A◯ 9.44 **B**◯ 1.07×10^{1} **C**◯ 1.21×10^{1}
D◯ 1.36×10^{1} **E**◯ 1.54×10^{1} **F**◯ 1.74×10^{1}
G◯ 1.97×10^{1} **H**◯ 2.22×10^{1}

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6 pt What is the power dissipated by resistor R_4?
(in `W`*)*

8.A◯ 9.24 **B**◯ 1.04×10^{1} **C**◯ 1.18×10^{1}
D◯ 1.33×10^{1} **E**◯ 1.51×10^{1} **F**◯ 1.70×10^{1}
G◯ 1.92×10^{1} **H**◯ 2.17×10^{1}

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6 pt A point charge Q = +1.21 μC moving in a uniform magnetic field of B = 1.92 T has a velocity of v = 5.79 × 10^5 m/s that is perpendicular to the magnetic field. If the magnetic field points out of the page and the charge moves to the West, then what is the direction of the resulting force? (In this problem we use the points of the compass for directions on the paper with North pointing to the top of the page, and 'into' and 'out of' to indicate directions with respect to the page.)

9. A◯ East
B◯ Into the page
C◯ West
D◯ South
E◯ Out of the page
F◯ North

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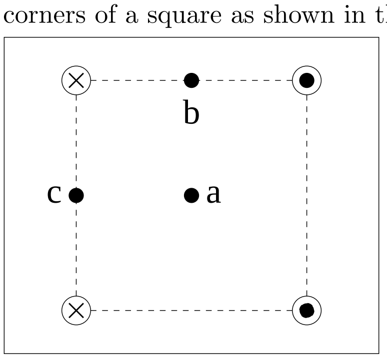
6 pt What is the magnitude of the force?
(in `N`*)*

10.A◯ 5.72×10^{-1} **B**◯ 6.46×10^{-1} **C**◯ 7.30×10^{-1}
D◯ 8.25×10^{-1} **E**◯ 9.32×10^{-1} **F**◯ 1.05
G◯ 1.19 **H**◯ 1.35

Four electric currents, equal in magnitude are arranged at the corners of a square as shown in the figure.



Two currents go into the page, and two are pointing out of the page. Point **a** is at the center of the square, and points **b** and **c** are in the middle of two of the sides.

5 pt What is the direction of the magnetic field at point **a**?

11. A◯ To the left.
B◯ To the right.
C◯ Down (to the bottom of the page).
D◯ Up (to the top of the page).
E◯ The magnetic field is zero at this point.

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5 pt What is the direction of the magnetic field at point **b**?

12. A◯ To the left.
B◯ The magnetic field is zero at this point.
C◯ Down (to the bottom of the page).
D◯ Up (to the top of the page).
E◯ To the right.

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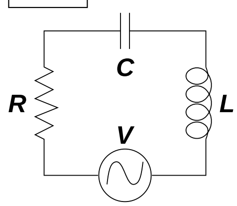
12 pt Consider the RLC circuit shown in the figure.



Select 'True', 'False' or 'Cannot tell' for the following statements.

▷ The current through the inductor is the same as the current through the resistor at all times.
13. A◯ True **B**◯ False **C**◯ Cannot tell

▷ The voltage drop across the resistor is the same as the voltage drop across the inductor at all times.
14. A◯ True **B**◯ False **C**◯ Cannot tell

▷ Energy is dissipated in the resistor but not in either the capacitor or the inductor.
15. A◯ True **B**◯ False **C**◯ Cannot tell

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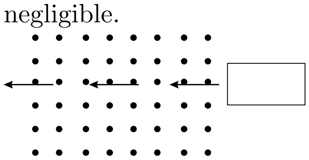
16 pt A square loop of wire with a small resistance is moved with constant speed from a field free region into a region of uniform B field (B is constant in time) and then back into a field free region to the left. The self inductance of the loop is negligible.



▷ When leaving the field the coil experiences a magnetic force to the left.

16. **A**◯ True **B**◯ False

▷ Upon entering the field, a clockwise current flows in the loop.

17. **A**◯ True **B**◯ False

▷ Upon leaving the field, a clockwise current flows in the loop.

18. **A**◯ True **B**◯ False

▷ When entering the field the coil experiences a magnetic force to the left.

19. **A**◯ True **B**◯ False

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6 pt A convex mirror has a radius of curvature whose magnitude is 43 cm. The mirror is positioned on a horizontal optical bench with its front surface at 0 cm. A 6.0 cm long fluorescent lamp oriented vertically is placed at +92 cm. What is the focal length of the mirror?

(in `cm`*)*

20.**A**◯ -7.0 **B**◯ -8.8 **C**◯ -11.0 **D**◯ -13.8
E◯ -17.2 **F**◯ -21.5 **G**◯ -26.9 **H**◯ -33.6

6 pt At what distance from the mirror can we find a sharp image of the lamp?

(in `cm`*)*

21.**A**◯ -1.3 **B**◯ -1.9 **C**◯ -2.7 **D**◯ -3.9
E◯ -5.7 **F**◯ -8.3 **G**◯ -12.0 **H**◯ -17.4

6 pt How tall is the image of the lamp?

(in `cm`*)*

22.**A**◯ 0.37 **B**◯ 0.54 **C**◯ 0.78 **D**◯ 1.14
E◯ 1.65 **F**◯ 2.39 **G**◯ 3.46 **H**◯ 5.02

6 pt If the convex mirror were replaced by a plane mirror and the lamp moved to 218 cm from the plane mirror, how tall would the image be?

(in `cm`*)*

23.**A**◯ 3.7 **B**◯ 4.4 **C**◯ 5.1 **D**◯ 6.0
E◯ 7.0 **F**◯ 8.2 **G**◯ 9.6 **H**◯ 11.2

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6 pt An object is placed between a converging lens and the focal point of the lens. Which of the following is true?

24. **A**◯ The image is smaller than the object, real and inverted.
B◯ The image is smaller than the object, virtual and inverted.
C◯ The image is smaller than the object, real and upright.
D◯ The image is bigger than the object, real and upright.
E◯ The image is bigger than the object, virtual and inverted.
F◯ The image is bigger than the object, virtual and upright.
G◯ The image is bigger than the object, real and inverted.
H◯ The image is smaller than the object, virtual and upright.

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6 pt Two slits separated by a distance of d = 0.13 mm are located at a distance of D = 0.52 m from a screen. The screen is oriented parallel to the plane of the slits. The slits are illuminated by a coherent light source with a wavelength of $\lambda = 537$ nm. A wave from each slit propagates to the screen. The interference pattern shows a peak at the center of the screen (m=0) and then alternating minima and maxima.
What is the pathlength difference between the waves at the second maximum (m=2) on the screen?

(in `mm`*)*

25.**A**◯ 7.85×10^{-4} **B**◯ 9.18×10^{-4} **C**◯ 1.07×10^{-3}
D◯ 1.26×10^{-3} **E**◯ 1.47×10^{-3} **F**◯ 1.72×10^{-3}
G◯ 2.01×10^{-3} **H**◯ 2.35×10^{-3}

6 pt What is the pathlength difference between the waves at the first **minimum** (m=0) on the screen?

(in `mm`*)*

26.**A**◯ 1.96×10^{-4} **B**◯ 2.29×10^{-4} **C**◯ 2.69×10^{-4}
D◯ 3.14×10^{-4} **E**◯ 3.68×10^{-4} **F**◯ 4.30×10^{-4}
G◯ 5.03×10^{-4} **H**◯ 5.89×10^{-4}

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6 pt A thin film of soap with n = 1.36 hanging in the air reflects dominantly red light with $\lambda = 651$ nm. What is the minimum thickness of the film?

(in `nm`*)*

27.**A**◯ 1.63×10^{1} **B**◯ 2.16×10^{1} **C**◯ 2.88×10^{1}
D◯ 3.82×10^{1} **E**◯ 5.09×10^{1} **F**◯ 6.77×10^{1}
G◯ 9.00×10^{1} **H**◯ 1.20×10^{2}

[*6 pt*] If astronauts could travel at v = 0.930c, we on Earth would say it takes (4.20/0.930) = 4.52 years to reach Alpha Centauri, 4.20 lightyears away. The astronauts disagree. How much time (in years) passes on the astronauts's clocks? Do not enter units.

28.A◯ 6.47×10^{-1} **B**◯ 7.57×10^{-1} **C**◯ 8.86×10^{-1}
D◯ 1.04 **E**◯ 1.21 **F**◯ 1.42
G◯ 1.66 **H**◯ 1.94

[*6 pt*] What is the distance (in lightyears) to Alpha Centauri as measured by the astronauts? Do not enter units.

29.A◯ 9.64×10^{-1} **B**◯ 1.13 **C**◯ 1.32
D◯ 1.54 **E**◯ 1.81 **F**◯ 2.11
G◯ 2.47 **H**◯ 2.89

[*6 pt*] When light of wavelength 421 nm falls on a potassium surface, electrons are emitted that have a maximum kineticenergy of 0.70 eV. Find the work function for potassium.
(in `eV`*)*

30.A◯ 1.66×10^{-1} **B**◯ 2.41×10^{-1} **C**◯ 3.49×10^{-1}
D◯ 5.07×10^{-1} **E**◯ 7.35×10^{-1} **F**◯ 1.07
G◯ 1.54 **H**◯ 2.24

[*6 pt*] What is the lowest frequency of light that will produce photoelectrons from potassium?
(in `Hz`*)*

31.A◯ 1.78×10^{14} **B**◯ 2.58×10^{14}
C◯ 3.74×10^{14} **D**◯ 5.42×10^{14}
E◯ 7.86×10^{14} **F**◯ 1.14×10^{15}
G◯ 1.65×10^{15} **H**◯ 2.40×10^{15}

[*6 pt*] Electrons are accelerated through a voltage difference of 17.9 kV inside a television's cathode ray tube. What is the final kinetic energy of the electrons?
(in `J`*)*

32.A◯ 1.22×10^{-15} **B**◯ 1.38×10^{-15}
C◯ 1.56×10^{-15} **D**◯ 1.76×10^{-15}
E◯ 1.99×10^{-15} **F**◯ 2.25×10^{-15}
G◯ 2.54×10^{-15} **H**◯ 2.87×10^{-15}

[*6 pt*] What is the de Broglie wavelength of the electrons?
(in `m`*)*

33.A◯ 4.98×10^{-12} **B**◯ 5.62×10^{-12}
C◯ 6.35×10^{-12} **D**◯ 7.18×10^{-12}
E◯ 8.11×10^{-12} **F**◯ 9.17×10^{-12}
G◯ 1.04×10^{-11} **H**◯ 1.17×10^{-11}

[*6 pt*] An electron has a speed of v = 0.982 c. What is its total energy (rest energy plus kinetic energy)?
(in `MeV`*)*

34.A◯ 8.87×10^{-1} **B**◯ 1.11 **C**◯ 1.39
D◯ 1.73 **E**◯ 2.16 **F**◯ 2.71
G◯ 3.38 **H**◯ 4.23

[*12 pt*] Some possible trasitions of the hydrogen atom are listed below:
A: $n_i = 4$, $n_f = 7$
B: $n_i = 3$, $n_f = 5$
C: $n_i = 3$, $n_f = 6$
D: $n_i = 2$, $n_f = 5$
E: $n_i = 6$, $n_f = 3$
F: $n_i = 5$, $n_f = 3$
G: $n_i = 5$, $n_f = 2$
H: $n_i = 7$, $n_f = 4$
where n_i and n_f are the initial and the final principal quantum numbers respectively.

▷ For which transition will the atom gain the most energy?
35. **A**◯ A **B**◯ B **C**◯ C **D**◯ D **E**◯ E **F**◯ F
G◯ G **H**◯ H

▷ Which transition will emit light with the shortest wavelength?
36. **A**◯ A **B**◯ B **C**◯ C **D**◯ D **E**◯ E **F**◯ F
G◯ G **H**◯ H
