

**Physics 126
Section B01**

**Friday Feb. 14 2014
Instructor: Wheelock, M.
CCIS 1-430 12:00 – 12:48**

**Winter 2014 – Exam 1
Exam is worth a total of 16 points**

**PLEASE DO NOT OPEN YOUR EXAM UNTIL YOU ARE TOLD TO DO SO.
You may begin filling out your Scan-Tron form.**

ON THE SCAN-TRON ANSWER SHEET, PLEASE ENTER THE FOLLOWING:

**YOUR NAME [Surname first, then a space, followed by your given name]
STUDENT ID NUMBER [seven digits]
SPECIAL CODES: see next page for exam version number**

*You **MUST** fill in the bubbles with the above info or your exam will not be marked. You will not be given extra time at the end of the exam to do so.*

There are 16 multiple-choice questions. Please read all answers and select the one best answer. Bubble in your answers in pencil on the Scan-tron Answer Sheet. Answers written on this handout will NOT be marked.

NO GRAPHING CALCULATORS OR PROGRAMMABLE CALCULATORS PERMITTED.

**TAKE A DEEP BREATH!
RELAX!**

Good luck!

**When the exam period is over, please stop working immediately.
Turn in your ScanTron sheet directly to your instructor or TA.
If you do not turn in your exam promptly it will not be accepted.**

IMPORTANT:

On your answer sheet under SPECIAL CODES

ENTER $J = 2$, $K = 2$

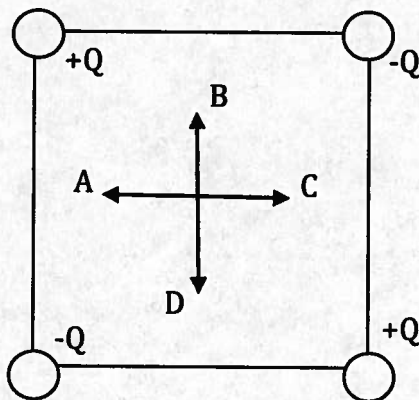
**Equation sheets are attached at the back.
You may carefully detach them.**

Corresponding question # on version 77

15

1. A group of charges are fixed to the corners of a square. All have the same magnitude of charge Q , but with signs as shown. Which arrow represents the net electric field at the centre of the square?

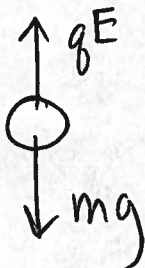
- A. A
- B. B
- C. C
- D. D
- E. None of the above; the electric field is zero at that location



16

2. A piece of dust has mass m and carries a net charge of 4.0×10^{-8} C. When placed in a uniform, vertical electric field $E = 1000$ N/C, the dust particle hangs motionless at equilibrium. What is the mass of the particle? [Note: gravity is not negligible.]

- A. 2.7×10^{-6} kg
- B. 8.0×10^{-5} kg
- C. 4.1×10^{-6} kg
- D. 9.8×10^{-7} kg
- E. 1.0×10^{-6} kg



Forces cancel out, so $qE = mg$ (magnitudes)

$$m = \frac{qE}{g} = \frac{(4.0 \times 10^{-8})(1000)}{9.81}$$

$$= 4.1 \times 10^{-6} \text{ kg}$$

Corresponding
question # on version 77

3. Water is flowing with volume flow rate Q and flow speed v through a horizontal cylindrical pipe of diameter D . When the water flows into a narrower section of pipe with diameter $= D/4$, the new flow speed and volume flow rate are...? Assume steady-state flow and zero viscosity.

- A. $4v$ and Q
- B. $16v$ and Q
- C. $8v$ and $Q/2$
- D. $v/4$ and $Q/4$
- E. $4v$ and $Q/4$

Q is constant (continuity)

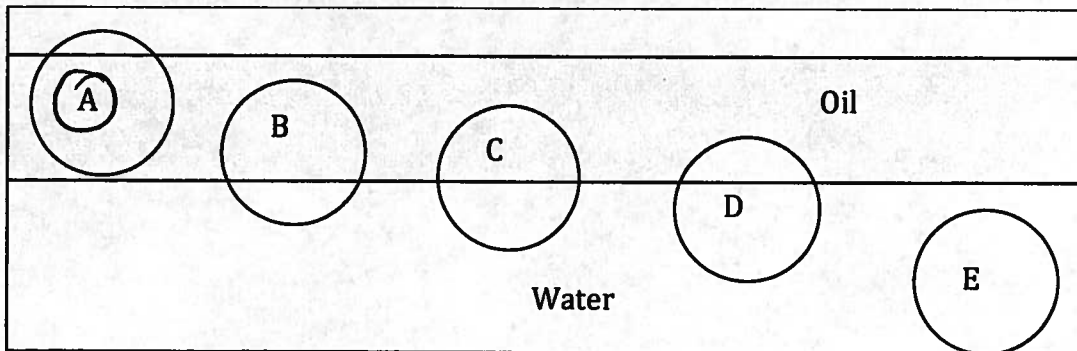
$$A_1 v_1 = A_2 v_2$$

$$v_2 = \left(\frac{A_1}{A_2} \right) v$$

$$= \left(\frac{\pi r_1^2}{\pi r_2^2} \right) v = \left(\frac{r_1}{r_2} \right)^2 v$$

$$= \left[\frac{D}{(D/4)} \right]^2 v = 16v$$

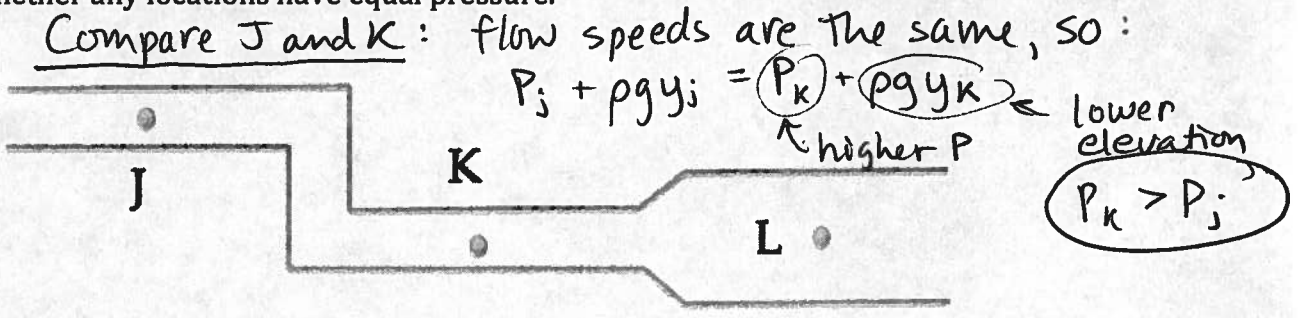
4. A bead has density $= 540 \text{ kg m}^{-3}$. It falls into a bucket containing water with a layer of oil floating on the water. Density of oil $= 600 \text{ kg m}^{-3}$. Which diagram best represents the position of the bead at equilibrium? *Bead floats in oil*



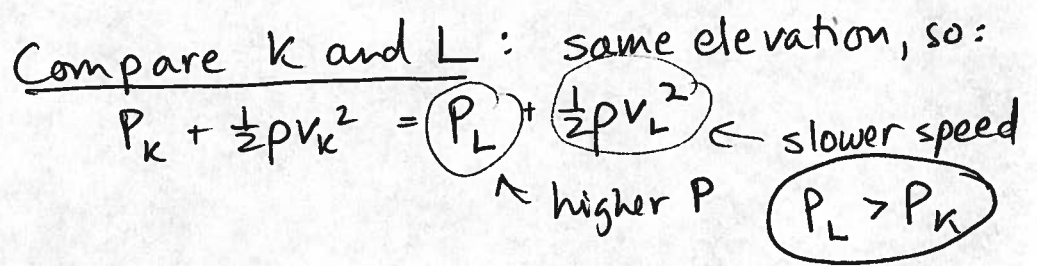
3

Use Bernoulli's equation.

5. The diagram below represents a pipe system in which an ideal fluid flows from left to right. Rank the locations J, K and L in order of decreasing pressure; indicate whether any locations have equal pressure.

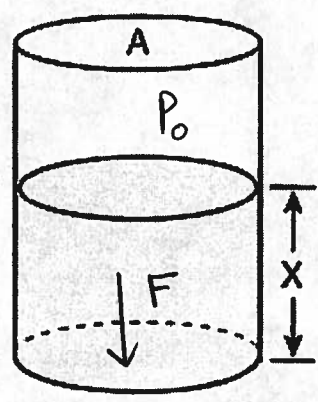


- A. $J > K > L$
- B. $J = K > L$
- C. $K = L > J$
- D. $L > K = J$
- E. $L > K > J$



4

6. A large industrial tank contains a liquid fuel, with a pressurized gas in the region above the fuel. The density of the liquid is 700 kg m^{-3} and its depth $x = 3.00 \text{ m}$. The tank has cross-sectional area $A = 7.00 \text{ m}^2$ and is completely sealed.



The downward force exerted by the fluid on the bottom surface of the tank is 1000 kN. What is the gas pressure above the liquid? $1 \text{ kN} = 10^3 \text{ N}$.

- A. $1.22 \times 10^5 \text{ Pa}$
- B. $1.05 \times 10^5 \text{ Pa}$
- C. $1.45 \times 10^5 \text{ Pa}$
- D. $2.12 \times 10^5 \text{ Pa}$
- E. $3.77 \times 10^5 \text{ Pa}$

$$P_{\text{tot}} = P_0 + \rho g x = \frac{F}{A}$$

$$P_0 = \frac{F}{A} - \rho g x$$

$$= \frac{1000 \times 10^3}{7} - (700)(9.81)(3)$$

$$= 1.22 \times 10^5 \text{ Pa}$$

5

7. In a chemical engineering lab, a fluid with viscosity η flows through a tube of radius R and length L . A second fluid with viscosity 2η flows through another tube of radius $3R$ and length $3L$. The same pressure difference is applied across both tubes. If Q represents the volume flow rate in the first tube, what is the volume flow rate in the second (wider) tube?

- A. $3Q$
 B. $1.5Q$
 C. $13.5Q$
 D. $27Q$
 E. none of the above



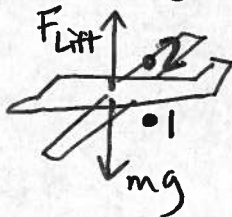
$$Q_1 = \frac{\Delta P \pi R^4}{8\eta L}$$

$$\begin{aligned} Q_2 &= \frac{\Delta P \pi (3R)^4}{8(2\eta)(3L)} = \frac{3^4}{(2)(3)} \left(\frac{\Delta P \pi R^4}{8\eta L} \right) \\ &= \frac{3^3}{2} (Q_1) \\ &= \frac{27}{2} Q_1 \end{aligned}$$

6

8. A Learjet has an effective wing area of 25 square meters and a weight of 65,000 N. Suppose the jet is flying horizontally at an altitude where the density of air is 1.00 kg m^{-3} and the air pressure just beneath the wings is 80,000 Pa. What is the air pressure just above the wings?

- A. 77,400 Pa
 B. 82,600 Pa
 C. 2600 Pa
 D. 62,600 Pa
 E. 80,000 Pa



no acceleration in vertical direction, so forces have equal magnitude:

$$F_{\text{lift}} = (P_1 - P_2)A = mg \quad \leftarrow \text{solve for } P_2$$

$$P_2 = -\frac{mg}{A} + P_1 = -\frac{65,000}{25} + 80,000$$

$$= 77,400 \text{ Pa}$$

7

9. A parallel plate capacitor is fully charged by a battery. If a dielectric material is then inserted between the capacitor plates while the battery remains connected, which of the following quantities would increase?

$\nearrow C$ increases

$\nearrow V$ is constant.

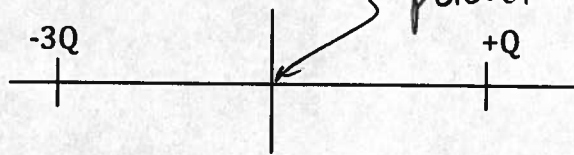
- A. the magnitude of electric field between the plates
- B. the potential difference across the plates
- C. the charge on each plate
- D. the energy stored in the capacitor
- E. both C and D

$Q = CV \rightarrow Q$ increases

$U = \frac{1}{2}CV^2 \rightarrow U$ increases

8

10. A pair of point charges $-3Q$ and $+Q$ are placed on the x-axis, equidistant from the origin, as shown. The work required by an external force to bring a positive charge from infinite distance and place it at the origin is...



potential is negative at the origin, so negative work is required.

- A. positive
- B. negative
- C. zero
- D. you need to know the magnitude of the third charge to answer this

9

11. Two identical positive charges repel each other. The arrows indicate the relative magnitude and direction of the electrostatic force exerted on each charge. If the magnitude of the left charge were doubled, which diagram below would best represent the forces acting on each charge? The distance separating the charges remains unchanged.



A.

B.

C.

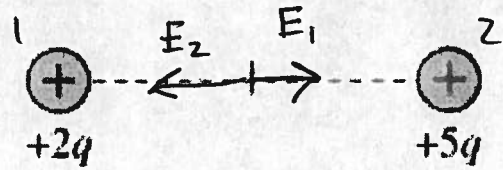
D.

$F = \frac{kq_1q_2}{r^2}$

Force is doubled; forces are equal in magnitude and opposite in direction.

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12. The charges at right are separated by a distance of 2.00 cm. They carry charges of $+2q$ and $+5q$, where the magnitude of $q = 1.00 \times 10^{-9}$ C. What is the magnitude of the electric field at the midpoint between the two charges?



- A. 7.0×10^4 N/C
- B. 1.4×10^5 N/C
- C. 2.8×10^7 N/C
- D. 2.7×10^5 N/C
- E. zero

$$E_{net} = E_2 - E_1$$

$$= \frac{kq_2}{r^2} - \frac{kq_1}{r^2}$$

where $r = (.01)$ m
(distance to midpoint)

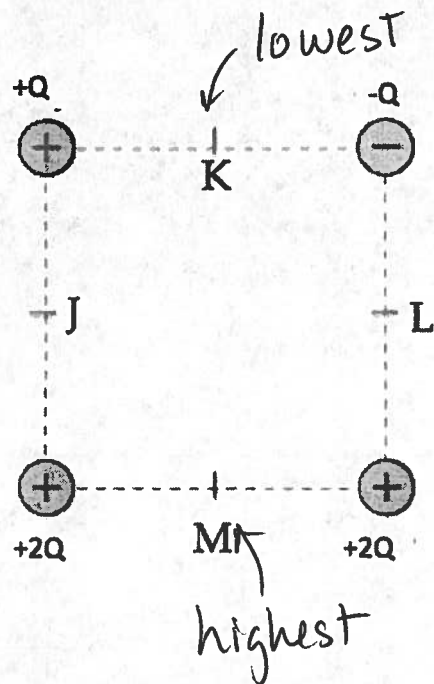
$$K_{net} = \frac{8.99 \times 10^9}{(.01)^2} (5 - 2) (\times 10^{-9} \text{ C})$$

$$= 2.7 \times 10^5 \text{ N/C}$$

11

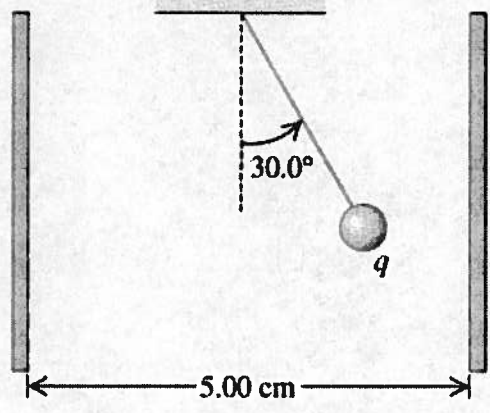
13. In the diagram at right, four charges are fixed in place at the corners of the square. The midpoint of each side of the square is labeled J, K, L, or M. Rank those locations in order of decreasing electric potential.

- A. $M > J > L > K$
- B. $L > M > J > K$
- C. $J > K = L > M$
- D. $K > L > M > J$
- E. $M > J > K = L$

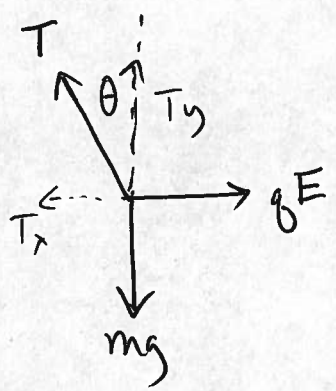


12

14. A small charged ball of mass = 2.0 g $\rightarrow = .002 \text{ kg}$ hangs from a thread in the region between the plates of a parallel plate capacitor. The potential difference between the plates is $10,000 \text{ V}$. The ball hangs at equilibrium at an angle as shown. What is the magnitude of the charge q on the ball?



- A. $5.7 \times 10^{-8} \text{ C}$
- B. $9.8 \times 10^{-8} \text{ C}$
- C. $6.0 \times 10^{-9} \text{ C}$
- D. $1.1 \times 10^{-9} \text{ C}$
- E. $2.3 \times 10^{-6} \text{ C}$



$$T_y = T \cos \theta = mg$$

$$T_x = T \sin \theta = qE$$

$$\frac{T \sin \theta}{T \cos \theta} = \frac{qE}{mg} = \tan \theta$$

$$q = \frac{mg \tan \theta}{E} = 5.7 \times 10^{-8} \text{ C}$$

$$E = \Delta V / d = 10,000 \text{ V} / .05 \text{ m} = 200,000 \text{ V/m}$$

13

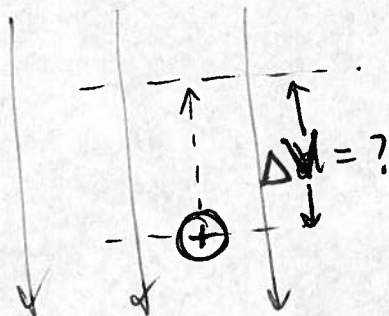
15. Refer to the previous problem. What is the sign of the charge q ?

- A. positive
- B. negative
- C. neutral
- D. it cannot be determined without additional information

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16. A charge of $+25 \mu\text{C}$ is placed in an electric field of magnitude $50,000 \text{ N/C}$. The electric field is uniform and directed downward. Suppose you expended 2.5 J of work in pushing the charge upward. Through what potential difference did you move the charge? Give magnitude only, don't worry about the sign. $1 \mu\text{C} = 10^{-6} \text{ C}$.

- A. $50,000 \text{ V}$
B. $100,000 \text{ V}$
C. 2.5 V
D. $25,000 \text{ V}$
E. 2500 V



$$\text{Work required} = \Delta U = q \Delta V$$

$$\Delta V = \frac{2.5 \text{ J}}{25 \times 10^{-6} \text{ C}} = 10^5 \text{ V}$$

MAKE SURE YOU HAVE BUBBLED IN your name, student ID, exam version number, and answers on the ScanTron sheet.

Turn in the ScanTron sheet only. You may keep this handout. Do not discuss your exam with anyone until after you have left the room.