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Faculté des sciences
Physique

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Physics

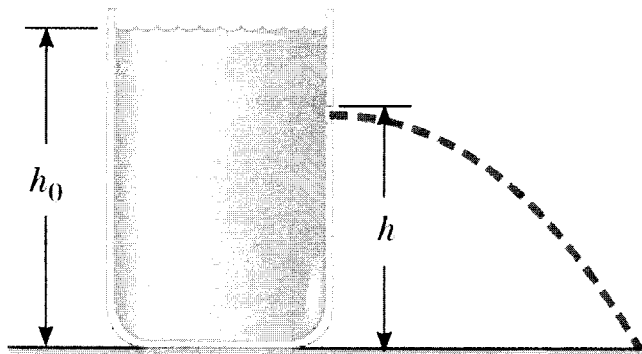
PHY 1122A

April 21, 2015
Final OPEN BOOK Examination: 3 hours

Dr. Z.M. Stadnik
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The answers should be entered carefully on a computer readable sheet using an HB pencil. At the end of the examination, only the computer sheet should be handed over to a proctor. The student can keep this questionnaire.

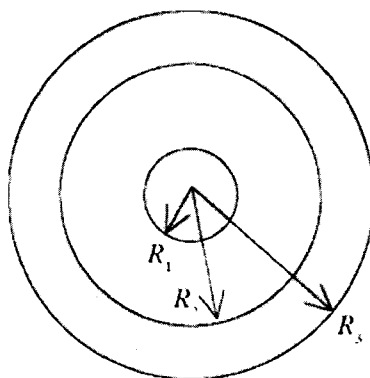
1.



A large storage tank is filled with water to a height h_0 . The tank is punctured at a height h above the bottom of the tank. For what value of h will the horizontal range of water spouting from the hole be the greatest?

- A) h_0
- B) $3h_0/4$
- C) $h_0/2$
- D) $h_0/4$
- E) 0

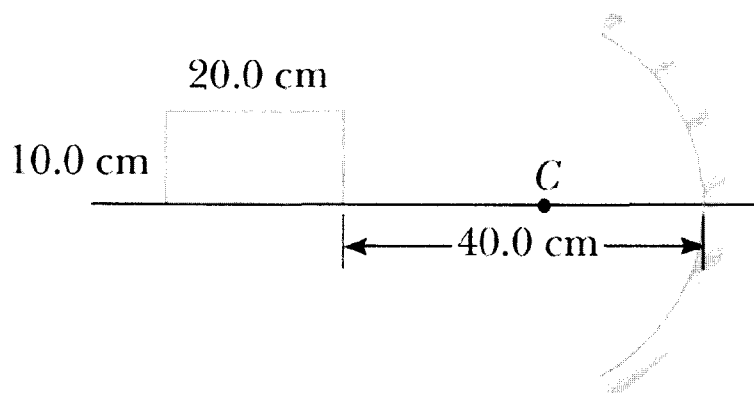
2.



Two concentric spheres are shown in the figure above. The inner sphere is a solid nonconductor and carries a charge of $+5.00 \mu\text{C}$ uniformly distributed over its outer surface. The outer sphere is a conducting shell that carries a net charge of $-8.00 \mu\text{C}$. No other charges are present. The radii shown in the figure have the values $R_1 = 10.0 \text{ cm}$, $R_2 = 20.0 \text{ cm}$, and $R_3 = 30.0 \text{ cm}$. Find the magnitude and direction of the electric field at the distance $r = 35.0 \text{ cm}$ from the center of the inner sphere.

- A) $2.20 \times 10^5 \text{ N/C}$, radially outward
- B) $2.20 \times 10^5 \text{ N/C}$, radially inward
- C) $5.88 \times 10^5 \text{ N/C}$, radially outward
- D) $5.88 \times 10^5 \text{ N/C}$, radially inward
- E) None of the above is correct.

3.

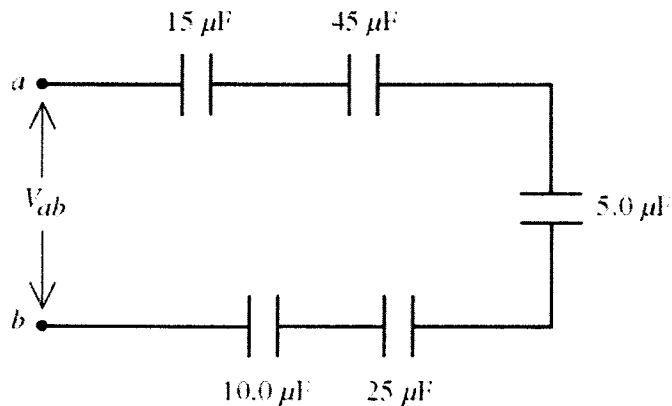


A rectangle $10.0 \text{ cm} \times 20.0 \text{ cm}$ is placed so that its right edge is 40.0 cm to the left of a concave spherical mirror, as in the figure above. The center of curvature of the mirror is point C . The radius of curvature of the mirror is 20.0 cm . What is the area of the image? (It might be helpful that you draw first the image formed by this mirror.)

- A) 3.56 cm^2
- B) 4.32 cm^2
- C) 4.57 cm^2
- D) 4.89 cm^2
- E) None of the above is correct.

4. A half-ring (semicircle) of uniformly distributed charge Q has radius R . What is the electrical potential at its center?
- A) $\frac{Q}{\pi\epsilon_0 R}$
 B) $\frac{Q}{2\pi\epsilon_0 R}$
 C) $\frac{Q}{3\pi\epsilon_0 R}$
 D) $\frac{Q}{4\pi\epsilon_0 R}$
 E) $\frac{Q}{5\pi\epsilon_0 R}$
5. A parallel-plate capacitor has a capacitance of 10 mF and is charged with a 20-V power supply. The power supply is then removed and a dielectric material of dielectric constant 5.0 is used to fill the space between the plates. How much energy is now stored by the capacitor?
- A) 50 mJ
 B) 100 mJ
 C) 200 mJ
 D) 300 mJ
 E) 400 mJ

6.



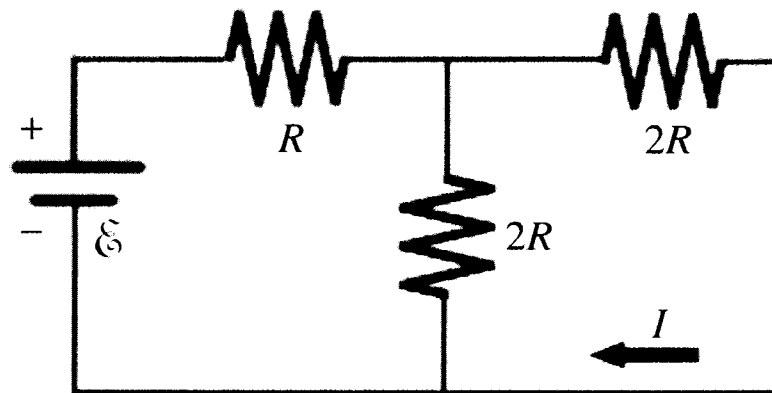
Five capacitors are connected across a potential difference V_{ab} as shown in the figure above. Because of the dielectrics used, each capacitor will break down if the potential across it exceeds 30.0 V. The largest that V_{ab} can be without damaging any of the capacitors is closest to

- A) 6.0 V.
 B) 30 V.
 C) 64 V.
 D) 150 V
 E) 580 V.

7. When a voltage difference is applied to a piece of metal wire, a 5.0-mA current flows through it. If this metal wire is now replaced with a silver wire having twice the diameter of the original wire, how much current will flow through the silver wire? The lengths of both wires are the same, and the voltage difference remains unchanged. (The resistivity of the original metal is $1.68 \times 10^{-8} \Omega \cdot \text{m}$, and the resistivity of silver is $1.50 \times 10^{-8} \Omega \cdot \text{m}$.)

- A) 21 mA
- B) 19 mA
- C) 11 mA
- D) 5.3 mA
- E) 4.6

8.



For the circuit shown in the figure above, $I = 0.400 \text{ A}$ and $R = 12.0 \Omega$. What is the value of the emf \mathcal{E} ?

- A) 24.0 V
 - B) 19.2 V
 - C) 16.6 V
 - D) 12.0 V
 - E) 11.2 V
9. A $4.0\text{-}\mu\text{F}$ capacitor that is initially uncharged is connected in series with a $4.0\text{-k}\Omega$ resistor and an ideal 15.0-V battery. How much energy is stored in the capacitor 15 ms after the battery has been connected?
- A) 0.11 mJ
 - B) 0.14 mJ
 - C) 0.17 mJ
 - D) 0.25 mJ
 - E) 0.47 mJ

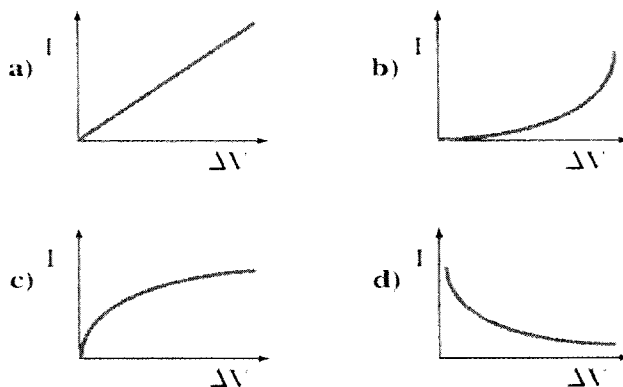
10. Consider a long optical fiber with index of refraction $n = 1.235$ that is surrounded by air. The end of the fiber is polished so that it is flat and perpendicular to the length of the fiber. A light ray from a laser is incident from air onto the center of the circular face of the end of the fiber. What is the maximum angle of incidence for the light ray such that it will be confined and transported by the optical fiber? (Neglect any reflection as the light ray enters the fiber.)
- A) 46.45°
 - B) 43.91°
 - C) 41.24°
 - D) 39.92°
 - E) 37.13°
11. A narrow beam of white light is incident at 25.0° onto a slab of heavy flint glass 5.50 cm thick. The indices of refraction of the glass at wavelength of 400 nm and 700 nm are 1.689 and 1.642, respectively. Find the width of the visible beam as it emerges from the slab.
- A) 0.336 mm
 - B) 0.367 mm
 - C) 0.391 mm
 - D) 0.412 mm
 - E) 0.435 mm
12. A goldfish is swimming inside a spherical plastic bowl of water, with an index of refraction of 1.33. If the goldfish is 9.0 cm from the wall of the 16.0-cm radius bowl, where does it appear to an observer outside the bowl?
- A) 8.12 cm outside the bowl
 - B) 8.12 cm inside the bowl
 - C) 7.86 cm outside the bowl
 - D) 7.86 cm inside the bowl
 - E) 9.17 cm outside the bowl
13. A thin converging lens is found to form an image of a distant building 24 cm from the lens. If an insect is now placed 16 cm from the lens, how far from the insect will its image be formed?
- A) 64 cm
 - B) 72 cm
 - C) 32 cm
 - D) 96 cm
 - E) 48 cm

14. A man can read the newspaper when it is held at 60 cm from his eye. What should the focal length of his contact lenses be to allow him to read the newspaper comfortably at a distance of 30 cm?
- A) -30 cm
 - B) 30 cm
 - C) -60 cm
 - D) 60 cm
 - E) 90 cm
15. Two extremely flat glass plates, 10.0 cm wide, touch at one end but are separated by a thin wire at the other end, forming a wedge. Light with wavelength 450 nm shines almost perpendicularly on the glass and forms fringes which are 1.80 mm apart. What is the diameter of the wire?
- A) 25.0 μm
 - B) 17.5 μm
 - C) 20.0 μm
 - D) 12.5 μm
 - E) 10.0 μm
16. A coating is being applied to reduce the reflectivity of a pane of glass to light with a frequency of 5.75×10^{14} Hz that is incident normally on the pane. If the material has an index of refraction of 1.375 and the glass has an index of refraction of 1.537, what is the minimum thickness the coating should have?
- A) 60.0 nm
 - B) 94.9 nm
 - C) 145 nm
 - D) 65.2 nm
 - E) 80.1 nm
17. A double slit illuminated with light of wavelength 588 nm forms a diffraction pattern on a screen 11.0 cm away. The slit separation is 2464 nm. What is the distance between the third and fourth bright fringes away from the central fringe?
- A) 23.9 cm
 - B) 5.96 cm
 - C) 5.59 cm
 - D) 4.27 cm
 - E) 2.63 cm

18. A slit of width $2.0 \mu\text{m}$ is used in a single slit experiment with light of wavelength 650 nm . If the intensity at the central maximum is I_0 , what is the intensity 11° from the center?
- A) $0.42I_0$
 - B) $0.39I_0$
 - C) $0.35I_0$
 - D) $0.31I_0$
 - E) $0.27I_0$
19. A thin beam of laser light of wavelength 514 nm passes through a diffraction grating having 3952 lines/cm . The resulting pattern is viewed on a distant curved screen that can show all bright fringes up to and including $\pm 90^\circ$ from the central spot. What is the total number of bright fringes that will show up on the screen?
- A) 4
 - B) 5
 - C) 8
 - D) 9
 - E) 10
20. Light of intensity I_0 and polarized horizontally passes through three polarizers. The first and third polarizing axes are horizontal, but the second one is oriented 20.0° to the horizontal. In terms of I_0 , what is the intensity of the light that passes through the set of polarizers?
- A) $0.780I_0$
 - B) $0.180I_0$
 - C) $0.442I_0$
 - D) $0.883I_0$
 - E) $0.714I_0$
21. A child is standing at the edge of a straight highway watching her grandparents' car driving away at 60.0 km/h . The air is perfectly clear and steady, and after 10.0 min the car's two red taillights (the average wavelength radiated by the red taillights is 650 nm) appear to merge into one. Assuming the diameter of the child's pupils is 5.00 mm , estimate the width of the car.
- A) 1.30 m
 - B) 1.47 m
 - C) 1.59 m
 - D) 1.67 m
 - E) 1.75 m

22. A conducting sphere of radius 18.0 cm carries an excess charge of $+13.0 \mu\text{C}$ and no other charges are present. The potential (relative to infinity) due to this sphere at a point 13.0 cm from its center is closest to
- A) zero.
 - B) 650 kV.
 - C) 580 kV.
 - D) 520 kV.
 - E) 900 kV.
23. A sample of helium (the molecular weight of helium is 4.00 g/mol) behaves as an ideal gas as energy is added by heat at constant pressure from 273 K to 393 K. If the gas does 20.0 J of work, what is the mass of helium present?
- A) 68.3 mg
 - B) 73.6 mg
 - C) 77.1 mg
 - D) 80.2 mg
 - E) 85.4 mg
24. A capacitor stores charge Q at a potential difference ΔV . If the voltage applied by a battery to the capacitor is doubled to $2\Delta V$, then
- A) the capacitance falls to half its initial value and the charge remains the same.
 - B) the capacitance and the charge both fall to half their initial values.
 - C) the capacitance and the charge both double.
 - D) the capacitance remains the same and the charge doubles.

25.



You perform a simple experiment on a light bulb. You steadily increase the voltage ΔV across the light bulb as you measure the current I through the bulb. In addition, as you increase voltage, you note that the temperature of the bulb increases. Which curve above would best represent your actual data?

- A) a)
- B) b)
- C) c)
- D) d)

26. The energy input to an engine is 3.00 times greater than the work it performs. What is its thermal efficiency?

- A) 0.333
- B) 0.667
- C) 0.111
- D) 0.222
- E) 1.00

27. Three engines operate between reservoirs separated in temperature by 300 K. The reservoir temperatures are as follows: Engine A: $T_H = 1000$ K, $T_C = 700$ K; Engine B: $T_H = 800$ K, $T_C = 500$ K; Engine C: $T_H = 600$ K, $T_C = 300$ K. Rank the engines in order of theoretically possible efficiency, from highest to lowest.

- A) A, B, C
- B) A, C, B
- C) B, C, A
- D) B, A, C
- E) C, B, A

28. Suppose that 2.00 kg of water at 0.00°C is mixed with an equal mass of water at 100°C . After equilibrium is reached, the mixture has a uniform temperature of 50.0°C . The specific heat of water is $4190\text{ J/kg}\cdot\text{K}$. What is the change in entropy of the system?
- A) 102 J/K
 - B) 203 J/K
 - C) 357 J/K
 - D) -357 J/K
 - E) zero
29. For an ideal gas at a certain temperature, the number of molecules of the gas with a speed greater than the most probable speed will be
- A) less than the number with a speed less than the most probable speed.
 - B) the same as the number with a speed less than the most probable speed.
 - C) greater than the number with a speed less than the most probable speed.
 - D) It depends on the gas and the temperature.
30. An apple is held completely submerged just below the surface of a container of water. The apple is then moved to a deeper point in the water. Compared to the force needed to hold the apple just below the surface, the force needed to hold it at a deeper point is
- A) larger.
 - B) the same.
 - C) smaller.
 - D) impossible to determine.
31. A glass tumbler with a flat base 2.6 mm thick contains an alcoholic liquid 86 mm in height. The indices of refraction of the glass and the liquid are 1.48 and 1.32 , respectively. The apparent thickness of the liquid, viewed at normal incidence from below the tumbler is closest to
- A) 69 mm .
 - B) 68 mm .
 - C) 67 mm .
 - D) 66 mm .
 - E) 65 mm .

V/T	F			
1	A	B	■	D E
2	A	■	C D E	
3	■	B C D E		
4	A	B C	■	E
5	A	B C D	■	
6	A	B	■	D E
7	■	B C D E		
8	A	■	C D E	
9	A	B	■	D E
10	■	B C D E		
11	A	B C D	■	
12	A	B C	■	E
13	A	B	■	D E
14	A	B C	■	E
15	A	B C	■	E
16	A	■	C D E	
17	■	B C D E		
18	A	B C D	■	
19	A	B C	■	E
20	■	B C D E		
21	A	B	■	D E
22	A	■	C D E	
23	A	B C	■	E
24	A	B C	■	E
25	A	B	■	D E
26	■	B C D E		
27	A	B C D	■	
28	A	■	C D E	
29	A	B	■	D E
30	A	■	C D E	
31	A	B C D	■	
32	A	B C D E		
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56	A	B C D E		
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58	A	B C D E		
59	A	B C D E		
60	A	B C D E		

V/T	F			
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63	A	B C D E		
64	A	B C D E		
65	A	B C D E		
66	A	B C D E		
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