Practice Problems for Final Exam, Spring 2024

Chapter 9 sect 5,6 , Chapter 10 sect.1-10, Chapter 11 sect. 1-4, 7-8, 12 , Chapter 12 sect. 1-7, Chapter 13 Sect. 1-8, Chapter 14 sect. 1-8, Chapter 15 sect. 1-2, 4-6, Chapter 16 Sect. 1-7 , Chapter 17sect. 1-2 Chapter 18 sect. 1-7, Chapter 19 sect. 1-4 Chapter 23 sect. 1-8, Chapter 24 sect. 3-4, 6

1. How large a force is necessary to stretch a 2.0-mm-diameter steel wire ($E = 2.0 \times 10^{11}$ N/m^2) by 1.0%?

A) 3.1×10^3 N
B) 6.3×10^3 N
C) 9.4×10^3 N
D) 1.3×10^4 N
E) 3.1×10^7 N

$\sigma = E \cdot \varepsilon = 2x10^{11}\text{Pa} \cdot 0.01 = 2x10^9$
$F = \sigma\pi r^2 = 2x10^9 \cdot \pi(0.001\text{m})^2 = 6300\text{N}$

2. Crew members attempt to escape from a damaged submarine 80 m below the surface. What force must they apply to a pop-out hatch of radius of 18 cm to push it out? Assume the density of ocean water 1025 kg/m^3.

A) 3.1×10^3 N
B) 6.3×10^3 N
C) 9.4×10^3 N
D) 8.2×10^4 N
E) 3.1×10^7 N

$F = pA = \rho g h \pi r^2 = 1025\text{kg/m}^3 \cdot 9.8\text{m/s}^2 \cdot 80\text{m} \cdot \pi(0.18\text{m})^2$

3. A block of wood has density 0.50 g/cm^3 and mass 1 500 g. It floats in a container of oil (the oil's density is 0.75 g/cm^3). What volume of oil does the wood displace?

A) 2000 cm^3
B) 3000 cm^3
C) 4000 cm^3
D) 5000 cm^3
E) 6000 cm^3

$mg = F_B$ $\quad mg = \rho g V \quad m = \rho V \quad V = 1500\text{g}/0.75\text{g/cm}^3 = 2000\text{ cm}^3$

4. A water hose of radius of 1.2 cm is used to fill a bucket of volume of 0.075 m^3. If it takes 2.2 min to fill the bucket, what is the speed at which the water leaves the hose?

A) 0.5 m/s
B) 1.3 m/s
C) 3.0 m/s
D) 4.9 m/s
E) 8.8 m/s

volume/time = Av $\quad v = 0.075\text{m}^3/(2.2x60 \cdot \pi \cdot 0.012\text{m}^2) = 1.3$ m/s

5. A sample of unknown material appears to weigh 300 N in air and 200 N when immersed in water. The density of the material is closest to

A) 1200 kg/m^3
B) 2000 kg/m^3
C) 3000 kg/m^3
D) 4000 kg/m^3
E) 6500 kg/m^3

300 N – 200 N = $\rho g V$ solve for V solve for density m/V

6. A 10 kg iron block (density = 7900 kg/m^3) is hanging from the rope. What is the tension in the rope if the block is immersed in a liquid of density of 850 kg/m^3?

A) 98 N

B) 86 N $V = m/V = 10kg/7900kg/m^3 = 1.27x10^{-3}m^3$ $F_b = \rho gV = 850kg/m^3 * 9.8m/s * 1.27x10^{-3}m^3 = 10.6N$

C) 72 N $T - mg + F_b = 0$ $T = mg - F_b = 98N - 11N = 87N$

D) 64 N

E) 55 N

7. If wind (density of air =1.29 kg/m^3) blows at 30 m/s parallel to a flat roof having an area of 475 m^2, what is the force exerted on the roof?

A) $2.76x10^5$ N, up

B) $8.75x10^5$ N, down

C) $4.26x10^6$ N, up $p_1 + ½\rho v_1^2 = p_2 + ½\rho v_2^2$ $p_1 - p_2 = ½\rho(v_1^2 - v_2^2) = ½ \cdot 1.29kg/m^3(30^2 -) = 580.5$ Pa

D) $6.16x10^6$ N, down $F = (p_1 - p_2)A = 580.5Pa \cdot 475\ m^2$

E) $1.23x10^7$ N, up

8. In a section of horizontal pipe with a diameter of 3.0 cm, the pressure is 100 kPa and water is flowing with a speed of 1.5 m/s. The pipe narrows to 2.0 cm. What is the pressure in the narrower region? Treat the water as an ideal incompressible fluid.

A) 95 kPa

B) 48 kPa $A_1v_1 = A_2v_2$

C) 44 kPa $p_1 + ½\rho v_1^2 = p_2 + ½\rho v_2^2$

D) 230 kPa

E) 67 kPa

9. The temperature of the iron cube, 5 cm on edge, should be changed by what amount for the volume of the cube to increase by 0.35 cm^3. (The coefficient of linear expansion of iron is 1.2 x 10^{-5} per ^{0}C)

A) 55^0C $\Delta V = V_0\beta\Delta T$ $V_0 = a^3$ $\beta = 3\alpha$

B) 167^0C $0.35cm^3 = (5cm)^3 3\alpha\Delta T$ solve for ΔT

C) 78^0C

D) 355^0C

E) 431^0C

10. For mercury to expand by 2% , what change in temperature is necessary? ($\beta = 180x10^{-6}/^0C$).

A) 400^0C $\Delta V = V_0\beta\Delta T$ $\Delta V/V_0 = \beta\Delta T$

B) 267^0C $0.02 = \beta\Delta T$

C) 111^0C

D) 8.2^0C

E) 5.5^0C

11. Approximately how many argon atoms are needed to fill the space between two panes of glass in a window, if the absolute gas pressure is 2 atm., the volume of the space is 0.2 m^3 , and the temperature is 30^0C? (1atm=$1.013x10^5$Pa, N_{av} = $6.023x10^{23}$/mol , R = 8.31 J/Kmol)

A) 9.7×10^{24} N

B) 5.6×10^{20} N

C) 1.3×10^{31} N pVT = nR T = 273+30^0C = 303 K p = 2x$1.013x10^5$Pa = $2.023x10^5$Pa

D) 6.5×10^{28} N solve for n

E) 6.5×10^{15} N N = nx$6.023x10^{23}$

12. A balloon originally has a volume of 1.0 m^3 when the gas in it is at 20°C and under a pressure of 1.0 atm. As it rises in the earth's atmosphere, its volume expands. What will be its new volume if its final temperature and pressure are -40°C and 0.10 atm?

A) 2.0 m^3 T_1=293K T_2-233K $p_1V_1/T_1 = p_2V_2/T_2$ $V_2 = p_1V_1T_2/p_2T_1$

B) 4.0 m^3

C) 6.0 m^3 V_2= 1atm*1m^3*233K/0.1m^3*293K

D) 8.0 m^3

A) 9.0 m^3

13. An 500 g aluminum electric tea kettle has a 500-W heating coil. How long will it take to heat up 1 kg of water from 18ºC to 98ºC in this kettle? The specific heat of aluminum is 900 J/kg·ºC and the specific heat of water is 4186 J/kg·ºC

A) 2 minutes

B) 7 minutes Pt = 0.5 kg·900J/kg^0C (98-18) + 1 kg·4186J/kg^0C(98-18)

C) 12 minutes

D) 22 minutes

E) 29 minutes

14. A 120 grams of ice at temperature 0^0C added to water was able to decrease the temperature of water from 26^0C to 11^0C. What was the mass of the water? (latent heat of fusion for water is 335000 J/kg; specific heat of water is 4186 J/kg^0C) .

A) 128 g

B) 236 g 0.120 kg·335000J/kg + 0.129·4186(11 -0) = m_w4186(26-11) solve for m_w

C) 349 g

D) 640 g

E) 891 g

15. How much heat must be added to 0.05 kg of copper at 25^0C to melt it completely? C_{cu} = 387 J/kg. L_f = $20.7x10^4$ J/kg, melting point T = 1083 ^0C

A) 5 kJ

B) 12 kJ

C) 25 kJ Q = mc(1083-25) + mL_F

D) 0.5 kJ

E) 31 kJ

16. A thermopane window consists of two glass panes, each 0.6 cm thick, with a 1-cm-thick sealed layer of air in between. If inside the room temperature is 23 ^{0}C and the outside temperature is 0^0 C, determine the rate of energy transfer through 1m^2 of the window. (k=0.84 J/smK k_{air} = 0.0234 J/smK)

A) 62 W
B) 58 W
C) 55 W
D) 65 W
E) 52 W

17. A radiator has an emissivity of 0.7 and its exposed area is 1.2 m^2. The temperature of the radiator is 85^{0}C and the surrounding temperature is 20^{0}C. What is the net heat flow rate from the radiator? (σ = 5.67x10^{-8} W/m^{2}K^4)
A) 855 W
B) 628 W $P = e\sigma A(358K^4 - 294K^4)$
C) 431 W
D) 325W
E) 100 W

18. A water heater is operated by a solar power. If the solar collector has an area of 6 m^2, and the intensity delivered by sunlight is 550 W/m^2, how long does it take to increase the temperature of 1000 kg of water from 20^{0}C to 60 ^{0}C? c=4186 J/kg^{0}C

A) 0.55 h
B) 2.00 h $(550\ W/m^2 \times 6m^2)t = mc\Delta T$ solve for time
C) 7.50 h
D) 14.0 h
E) 21.0 h

19. How long will it take to transfer 5.5 MJ of heat through a 2.25 m^2 pane of 3 mm thick glass (k=0.84 J/sm^0 C) if the temperature difference is 12^0 C.
A) 208 hr
B) 20.8 hr $Q = (kA\Delta T/l)t$ $t = 5.5x10^6\ J\cdot 0.003\ m/(0.84\cdot 2.25m^2\cdot 12^0C$
C) 12.1 min
D) 75 s
E) 15 s

20. Gas in a container expands at a constant pressure of 3 atm. Find the work done by the gas if the initialvolume of the gas is 5 liters and the final volume is 10 liters. (1 atm = 1.013x10^5 Pa, 1L = 0.001 m^3)
A) 0 J
B) 150 J $W = p(V_f - V_i)$ $= 3x1.013x10^5\ Pa\ (5x10^{-3}m)$
C) 15 J
D) 1 500 J
E) 1.5 J
21. A Carnot engine takes 2000 J from a hot reservoir at 500 K, does some work, and discards some heat to cold reservoir at 350 K. The work done by the engine is closest to

A) 3600 J
B) 3000 J e=1-350K/500K = 0.3 W = eQ_h
C) 2400 J
D) 1200 J
E) 600 J

22. A refrigerator has a coefficient of performance of 4.0. When removing 2.4×10^4 J from inside the refrigerator, how much energy is sent into the environment?

A) 9.6×10^4 J
B) 3.0×10^4 J
C) 1.8×10^4 J COP = Q_C /W $Q_H = Q_C+W$ solve for Q_h
D) 0.60×10^4 J
E) 0.20×10^3 J

23. A mass of 0.40 kg, hanging from a spring with a spring constant of 80 N/m, is set into an up-and-down simple harmonic motion. What is the speed of the mass when moving through the equilibrium point? The starting displacement from equilibrium is 0.10 m.

A) zero
B) 1.4 m/s
C) 2.0 m/s $v_{max} = A\omega$ $\omega =(k/m)^{0.5}$
D) 3.4 m/s
E) 6.5 m/s

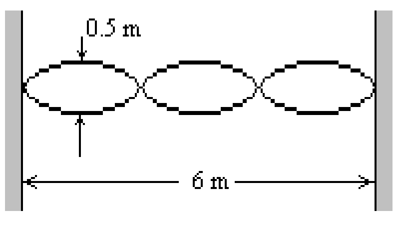
24. A 0.3-kg block, attached to a spring, executes simple harmonic motion according to x = 0.8 cos (35 rad/s·t), where x is in meters and t is in seconds. Find the spring constant of the spring.

A) 22 N/m
B) 1500 N/m ω^2 m=k
C) 368 N/m
D) 160 N/m
E) 2.8 N/ m

25. A string of linear mass 0.0015 kg/m is under a tension of 40 N. What should its length be if the frequency of the second harmonic is 440 Hz?

A) 0.26 m $v = (F/\mu)^{0.5} = (40N/0.0015kg/m^2)^{0.5}$ =163 m/s
B) 0.37 m
C) 0.41 m f = (v/2L)n solve for L
D) 0.85 m
E) 1.5 m

26. A standing wave of frequency 45 Hz is set up on a string 6 m long as shown. What is the speed at which wave propagates on the string?



A) 25 m/s
B) 45 m/s $\lambda = 2L/n = 12m/3 = 4m$
C) 100 m/s $v = \lambda f$
D) 180 m/s
E) 220 m/s

27. The intensity at a distance of 4.0 m from a source that is radiating equally in all directions is 9.85×10^{-7} W/m^2. What is the intensity level in dB at a distance of 6 m?

A) 17.8 dB
B) 20.0 dB $I = P/4\pi r^2$
C) 26.5 dB
D) 32.2 dB $\beta = 10dB\log(I/I_o)$
E) 56.4 dB

28. The intensity of a certain sound wave is $2x10^{-7}$ W/m^2. If its intensity is raised by 30 decibels, what is the new intensity in W/m^2?

A) $6x10^{-5}$ W/m^2 $\beta_2 - \beta_1 = 10dB\log(I_1/I_2)$
B) $5x10^{-4}$ W/m^2
C) $2x10^{-4}$ W/m^2
D) $6 x10^{-3}$ W/m^2
E) $2x10^{-2}$ W/m^2

29. A 500-Hz whistle is moved toward a listener at a speed of 10.0 m/s. At the same time, the listener moves at a speed of 20.0 m/s in a direction away from the whistle. What is the apparent frequency heard by the listener? (The speed of sound is 340 m/s.)
A) 463 Hz
B) 485 Hz
C) 533 Hz f = 500Hz[(343 m/s-20m/s)/(343m/s-10m/s)]
D)547 Hz
E) 562 Hz

30. An organ pipe, open at both ends, is 2.2 m long. If the velocity of sound in air is 343 m/s, the frequency of third harmonic of this pipe is:

A) 116 Hz $f= v\cdot n/2L$
B) 234 Hz
C) 366 Hz $f =343m/s\cdot 3/(2\cdot 2.2m)$
D) 499 Hz
E) 5640 Hz

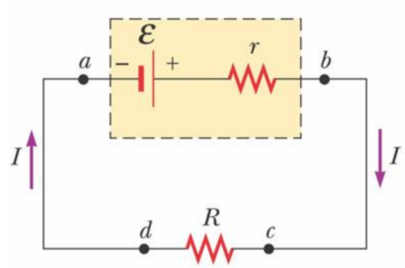
31. The wiring in a house must be thick enough so it doesn't become so hot to start a fire. What diameter must a copper wire ($\rho = 1.68 \times 10^{-8}\ \Omega m$) be if it is to carry a maximum current of 30 A and produce no more than 1.6 W of heat per meter of length?

A) 0.025 mm
B) 0.44 mm $\qquad$ $P = I^2R$ solve for R $\qquad$ $R = (1.68 \times 10^{-8}\ \Omega m \cdot 1m)/\pi r^2$
C) 3.5 mm
D) 8.4 mm $\qquad$ solve for r , d=2r
E) 2.2 cm

32. What is the resistance of a light bulb that uses an average power of 125 W when connected to ac power source with peak voltage of 250 V?

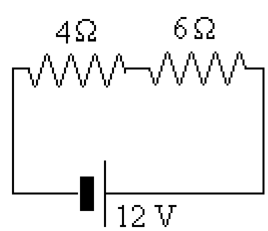
A) 50 Ω
B) 90 Ω
C) 120 Ω $\qquad$ $V_{max} = V_{rms} \cdot \sqrt{2}$ $\qquad$ solve for V_{rms} $\qquad$ $P = (V_{rms})^2/R$ $\qquad$ solve for R
D)150 Ω
E) 250 Ω

33. If the terminal voltage of the 9- V battery connected across 10- Ω resistor R is 8.4 V, what is the internal resistance of the battery?



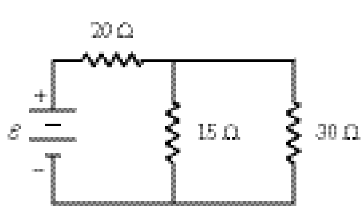
A) 0. 9 Ω $\qquad$ $8.4\ V = I \cdot 10\Omega$ $\qquad$ solve for I
B) 8.0 Ω
C) 0.70 Ω
D) 6.4 Ω $\qquad$ $9V - 8.4\ V = Ir$ $\qquad$ solve for r
E) 0.25 Ω

34. The power dissipated in the 6 Ω resistor is:



A)2.25W
B)8.64W
C)9.56W $\qquad$ $12V = I(4\Omega + 6\Omega)$ solve for I
D)12.5W $\qquad$ $P = I^2R$
E)24.0W

Consider the circuit below.



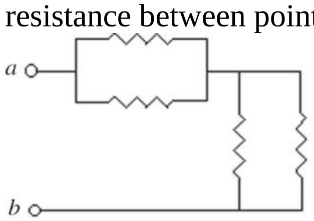
35. What is the current in the 20-Ω resistor when emf = 9.0 V?

A) 0.20 A
B) 0.30 A $R_{eq} = (1/15\Omega+1/30\Omega)^{-1}+20\Omega = 10\Omega+20\Omega = 30\Omega$ $I_{20\Omega}=\varepsilon/R_{eq} = 9V/30\Omega = 0.3A$
C) 0.10 A
D) 0.26 A
E) 0.60 A

36. What is the current in the 15-Ω resistor when emf = 9.0 V?

A) 0.20 A V' = 0.3A*10Ω=3V $I_{15} = 3V/15\Omega = 0.2$ A
B) 0.30 A
C) 0.10 A
D) 0.26 A
E) 0.60 A

37. The resistors in the circuit shown in the figure each have a resistance of 700 Ω. What is the equivalent resistance between points *a* and *b* of this combination?



$R_{eq}= (1/700\Omega+1/700\Omega)+ (1/700\Omega+1/700\Omega) = 700\Omega$

A) 700 Ω
B) 2800 Ω
C) 175 Ω
D) 1400 Ω
E) 475 Ω

38 The speed of light in a certain material is measured to be 2.2×10^8 m/s. If the wavelength of the light entering this material is 630 nm, what is the wavelength of the light in the material? ($c = 3.0 \times 10^8$ m/s)
A) 300 nm
B) 380 nm c = vn solve for n $\lambda_o = \lambda n$ solve for λ
C) 450 nm
D) 630 nm
E) 882 nm

39. How far does light travel in 1.0 μs? ($c = 3.0 \times 10^8$ m/s)
A) 3.0×10^{14} m
B) 0.30 km
C) 3.0 m x = vt
D) 30 cm
E) 12 km

40. A 1.5 cm high object is placed 20 cm from the concave mirror with radius of curvature 30 cm. Determine the position of the image and its height

A) 60 cm, 4.5 cm

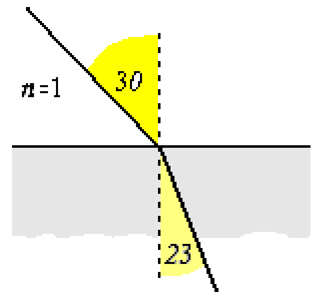
B) 60 cm , 17 cm $\quad d_i = (1/f - 1/d_o)^{-1} \quad d_i = (1/15-1/20)^{-1} = 60$ cm $\quad m = 60$ cm/20cm = 3 $\quad h' = h \cdot m$

C) 30 cm, 1.5 cm $\quad f = r/2$

D) 15 cm, - 12 cm

E) 30 cm, 6.0 cm

41. Light enters a substance from air at 30.0^0C to the normal. It continues through the substance at 23.0^0 to the normal. What would be the critical angle for this substance?



A) 63.9^0

B) 51.4^0

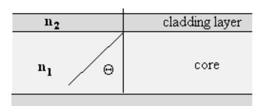
C) 36.7^0

D) 12.6^0 $\quad n_1 \sin 30^o = n_2 \sin 23^o \quad$ solve for n_2

E) 16.6^0

$n_2 \sin \theta_{cr} = n \sin 90^0$ solve for θ_{cr}

42. An optical fiber consists of a core made of glass of n_1 = 1.68 surrounded by a cladding made layer of plastics with index of refraction n_2 = 1.42. The critical angle θ_c for the interface between the glass and the plastics is closest to



A) 58.0^0 $\quad 1.68 \sin \theta_{cr} = 1.42 \sin 90^0 \quad$ solve for θ_{cr}

B) 42.0^0

C) 36.5^0

D) 22.0^0

E) 16.3^0

43. A drawing is placed 40 cm in front of a thin lens. If a virtual image forms at a distance of 50 cm from the lens, on the same side as the drawing, what is the focal length of the lens?

A) 45 cm $\quad d_0$=40 cm d_i = - 50 cm

B) 75 cm $\quad (40\text{cm})^{-1} - (50\text{cm})^{-1} = f^{-1} \quad$ solve for f

C) 90 cm

D) 200 cm

E) +45 cm

44. How far from a +50-mm focal length lens, such as is used in many 35-mm cameras, must an object be placed so it will form a real image at a distance of 197 mm.

A) 46 mm

B) 52 mm $\quad f^{-1} = d_o^{-1} + d_i^{-1} \quad$ solve for d_o

C) 58 mm

D) 67 mm

E) 72 mm

45. Monochromatic light from a helium-neaon laser (wavelength 632.8 nm) is incident normally on a diffraction grating containing 6000 lines/cm. At what angle the first order maximum can be observed?

A) 5.2^0 $\quad$ $d = 6000^{-1} = 1.67x10^{-4}cm = 1.67x10^{-6}m$
B) 11.8^0
C) 22.3^0
D) 31.4^0 $\quad$ $d\sin\theta = m\lambda$ $\quad$ m=1 $\quad$ solve for θ
E) 43.2^0

46. A diffraction grating with 4000 lines per cm produces a second -order bright fringe at an angle of 38.5^0. What is the wavelength of the light shining on the grating?

A) 345 nm $\quad$ $d=0.01m/4000 = 2.5x10^{-6}$ m
B) 490 nm $\quad$ $d\sin\theta =m\lambda$ $\quad$ m=2 $\quad$ solve for λ
C) 550 nm
D) 620 nm
E) 778 nm