5. Suppose you have a coffee mug with a circular cross section and vertical sides (uniform radius). What is its inside radius if it holds 375 g of coffee when filled to a depth of 7.5 cm? Assume coffee has the same density as water.
R=4 cm

11. As a woman walks, her entire weight is momentarily placed on one heel of her high-heeled shoes. Calculate the pressure exerted on the floor by the heel if it has an area of 1.5 cm^2 and the woman's mass is 55 kg. Express the pressure in Pa. (In the early days of commercial flight, women were not allowed to wear high-heeled shoes because aircraft floors were too thin to withstand such large pressures.)
P=3.59e6 N/m^2

19. How much force is exerted on one side of an 8.5 in by 11 in sheet of paper by the atmosphere? How can the paper withstand such a force? 1370 lbs, Po=1.0132e5 Pa

22. The left side of the heart creates a pressure of 120 mm Hg by exerting a force directly on the blood over an effective area of 15 cm^2 . What force does it exert to accomplish this? Hg density = 13.6e3 kg/m^3, F=24 N

24. How much pressure is transmitted in the hydraulic system considered in Example 11.6? Express your answer in pascals and in atmospheres. 2.55e7 Pa = 2.51 atm

35. Assuming bicycle tires are perfectly flexible and support the weight of bicycle and rider by pressure alone, calculate the total area of the tires in contact with the ground. The bicycle plus rider has a mass of 80 kg, and the gauge pressure in the tires is 3.5e5 Pa. 22.4 cm^2

41. A rock with a mass of 540 g in air is found to have an apparent mass of 342 g when submerged in water. (a) What mass of water is displaced? (b) What is the volume of the rock? (c) What is its average density? Is this consistent with the value for granite? water= 198 g, density=2.73 g/mL, yes

42. Archimedes' principle can be used to calculate the density of a fluid as well as that of a solid. Suppose a chunk of iron with a mass of 390.0 g in air is found to have an apparent mass of 350.5 g when completely submerged in an unknown liquid. (a) What mass of fluid does the iron displace? (b) What is the volume of iron, using its density as given in Table 11.1 (c) Calculate the fluid's density and identify it.
fluid=39.5 g, density Fe=7.8 g/mL, ethyl alcohol = .79 g/mL

54. What is the pressure inside an alveolus having a radius of 2.5e-4 m if the surface tension of the fluid-lined wall is the same as for soapy water? You may assume the pressure is the same as that created by a spherical bubble.
γ=.037 N/m, P=592 N/m^2

64. Calculate the contact angle θ for olive oil if capillary action raises it to a height of 7.07 cm in a glass tube with a radius of 0.1 mm. Is this value consistent with that for most organic liquids?
γ=.032 N/m, ρ=.92 g/mL, θ = 5°

iQuizt3.pdf pp 13-20

1. What is the average flow rate in cm^3/s of gasoline to the engine of a car traveling at 100 km/h if it averages 10 km/L?
2.78 cm^3/s
How fast is the gasoline moving if the supply tube has a diameter of .5 cm? 14.2 cm/s

Water flows through a pipe as shown in the figure. The pressure and velocity at point 1 are respectively
1.9e5 Pa and 1.25 m/s. The radius of the pipe at points
1 and 2 are respectively 3.3 cm and 1.2 cm. If the vertical distance between points 1 and 2 is 2.75 m, determine the following.
(a) speed of flow at point 2 (9.45 m/s)
(b) pressure at point 2 (1.18e5 Pa)
(c) volume flow rate of the fluid through the pipe (4.3 L/s)

23. (a) What is the pressure drop due to the Bernoulli effect as water goes into a 3 cm diameter nozzle from a
9 cm diameter fire hose while carrying a flow of 40 L/s?
1.58e6 Pa

24. (a) Using Bernoulli's equation, find the equation for fluid speed v for a pitot tube, like the one in Figure 12.7(b), h is the height of the manometer fluid, ρ' is the density of the manometer fluid, ρ is the density of the moving fluid, and g is the acceleration due to gravity. (Note that v is indeed proportional to the square root of h , as stated in the text.) (b) Calculate v for moving air if a mercury manometer's h is 0.2 m. (144 m/s)
air density=1.29 kg/m^3, Hg density = 13.7e3 kg/m^3

29. (a) Calculate the retarding force due to the viscosity of the air layer between a cart and a level air track given the following information: air temperature is 20°C (so η=.0181e-3), the cart is moving at 0.4 m/s, its surface area is 2.5e-2 m^2, and the thickness of the air layer is 6.e-5 m
F=3.02e-3 N

31. A glucose solution being administered with an IV has a flow rate of 4 mL/min . What will the new flow rate be if the glucose is replaced by whole blood having the same density but a viscosity 2.5 times that of the glucose? All other factors remain constant. ratios: 4/2.5=1.6 mL/min

47. An oil gusher shoots crude oil 25 m into the air through a pipe with a 0.1 m diameter. Neglecting air resistance but not the resistance of the pipe, and assuming laminar flow, calculate the gauge pressure at the entrance of the 50 m long vertical pipe. Take the density of the oil to be 900 kg/m^3 and its viscosity to be 1 N s/m^2
Note that you must take into account the pressure due to the 50 m column of oil in the pipe.

estimate exit speed: sqrt(2 g h)=22.14 m/s
(Note: for Poiseuille flow the max speed is 2x average)
Reynolds # = .1*900*22.1/1=1989 (nearly turbulent)
ΔP=v 8ηL/r^2=3.5e6 Pa
P=ρgh+ ΔP =3.98e6 Pa

64. Oxygen reaches the veinless cornea of the eye by diffusing through its tear layer, which is 0.5 mm thick. How long does it take the average oxygen molecule to do this?
t=x^2/2 D, D=1e-9; 125 s

osmotic pressure = i M R T

6. One of the hottest temperatures ever recorded on the surface of Earth was 134°F in Death Valley, CA. What is this temperature in Celsius degrees? What is this temperature in Kelvin? 57°C, 330 K

17. (a) If a 500 mL glass beaker is filled to the brim with ethyl alcohol at a temperature of 5°C, how much will overflow when its temperature reaches 22°C ? (b) How much less water would overflow under the same conditions?
β C2H5OH=1100e-6 1/K, β H2O=210e-6 1/K,
9.35 mL, 1.79 mL, neglect β pyrex ˜ 5% of water

28. Calculate the number of moles in the 2 L volume of air in the lungs of the average person. Note that the air is at 37°C (body temperature). 7.86e-2 mol

31. An expensive vacuum system can achieve a pressure as low as 1e-7 N/m^2 at 20°C . How many atoms are there in a cubic centimeter at this pressure and temperature?
2.47e7 atoms/cm^3

37. (a) What is the gauge pressure in a 25°C car tire containing 3.6 mol of gas in a 30 L volume? (b) What will its gauge pressure be if you add 1 L of gas originally at atmospheric pressure and 25°C ? Assume the temperature returns to 25°C and the volume remains constant.
1.96e5 Pa, 2.00e5 Pa

Initially you have 5 quarts of room temperature (70°F) air at 15 psi (absolute). You compress the air down to 1 quart, which raises its temperature to 550°F. What is the gauge pressure?
1 atm=14.7 psi, absolute zero= -460°F
P2=143 (absolute) = 128.3 (gauge) psi

42. The escape velocity of any object from Earth is 11.2 km/s. (b) At what temperature would oxygen molecules (molecular mass is equal to 32 g/mol) have an rms velocity equal to Earth's escape velocity?
T=11.2e3^2*.032/(3*R)=1.61e5 K

Our atmosphere is made up of N2 (28 g/mol), O2 (32 g/mol), Ar (40 g/mol) for an average of about 29 g/mol. Find the rms speed at 300 K . sqrt(3 R 300/.029)=508 m/s

63. What is the dew point (the temperature at which 100% relative humidity would occur) on a day when relative humidity is 39% at a temperature of 20°C ?
.39*17.2=6.71 -> bit less than 5°C
linear interpolation: 0->4.84, 5->6.8...4.77°C

68. If you want to cook in water at 150°C, you need a pressure cooker that can withstand the necessary pressure. (a) What pressure is required for the boiling point of water to be this high? (b) If the lid of the pressure cooker is a disk 25 cm in diameter, what force must it be able to withstand at this pressure? From Table 13.5, vapor pressure =4.76e5 Pa
F=(4.76e5-1.01e5)*pi*.125^2=1.84e4 N

You are driving to the top of Pikes Peak (alt=4302 m) from Colorado Springs (alt=1839 m) on a hot day (105°F) with the barometric pressure of 90e3 Pa, and the density of air 1 kg/m^3. Your tires show a gauge pressure of 30 psi. What is the gauge pressure of your tires on the mountain top where the temperature is freezing?
pressure at top=90e3-1*9.8*(4302-1839) assuming constant density
=65862 Pa x0.000145038=9.55 psi ; 90e3x0.000145038=13.1 psi
absolute tire pressure at top= (30+13.1)*(460+32)/(105+460)=37.5
gauge pressure=37.5-9.55=28 psi

c (J/gK) Al=.9, liquid H_2O=4.186, solid H_2O=2.09
latent heats water (J/g): fusion:334, vapor:2256

13. (a) How much heat transfer is required to raise the temperature of a 0.750 kg aluminum pot containing 2.5 kg of water from 30°C to the boiling point and then boil away 0.750 kg of water?
.9*750*70+4.186*2500*70+750*2256=2.47e6 J

24. A 0.050 kg ice cube at -30°C is placed in 0.400 kg of 35°C water in a very well-insulated container. What is the final temperature?
2.09*50*30+334*50+50*4.186*(x-0)+400*4.186*(x-35)=0; x=20.6°C

25. If you pour 0.010 kg of 20°C water onto a 1.2 kg block of ice (which is initially at -15°C), what is the final temperature? You may assume that the water cools so rapidly that effects of the surroundings are negligible.
1200*2.09(x+15)+10*4.186(0-20)-10*334+10*2.09*(x-0)=0;
x= -13.2°C

A 250 g block of aluminum is pulled from a container of liquid nitrogen (T = -196°C) and placed in 400 g of water which initially had a temperature of 20°C. The final state consists of everything at 0°C with 15 g of ice formed. Find the specific heat of the aluminum.
250*c*196+400*4.186*(0-20)-15*334=0; c=.786 J/gK

39. Suppose a person is covered head to foot by wool clothing with average thickness of 2 cm and is transferring energy by conduction through the clothing at the rate of 50 W. What is the temperature difference across the clothing, given the surface area is 1.4 m^2? kwool=.04 J/s m K, ΔT=17.9°C

59. Find the net rate of heat transfer by radiation from a skier standing in the shade, given the following. She is completely clothed in white (head to foot, including a ski mask), the clothes have an emissivity of 0.2 and a surface temperature of 10°C , the surroundings are at -15°C, and her surface area is 1.6 m^2 . P=-36 W, σ=5.67e-8 J/s m^2 K^4

73.Heat transfers from your lungs and breathing passages by evaporating water. (a) Calculate the maximum number of grams of water that can be evaporated when you inhale 1.5 L of 37°C air with an original relative humidity of 40%. (Assume that body temperature is also 37°C .) (b) How many joules of energy are required to evaporate this amount? (c) What is the rate of heat transfer in watts from this method, if you breathe at a normal resting rate of 10 breaths per minute? Lv=2430 J/g, saturated=44 g/m^3 (all at 37°C)
P=16 W

63. A large body of lava from a volcano has stopped flowing and is slowly cooling. The interior of the lava is at 1200°C , ts surface is at 450°C , and the surroundings are at 27°C
a) Calculate the rate at which energy is transferred by radiation from 1 m^2 of surface lava into the surroundings, assuming the emissivity is 1. (b) Suppose heat conduction to the surface occurs at the same rate. What is the thickness of the lava between the 450°C surface and the 1200°C interior, assuming that the lava's conductivity is the same as that of brick? kbrick=.84 J/s m K, P=-15 kW, d=4.2 cm

2. How much heat transfer occurs from a system, if its internal energy decreased by 150 J while it was doing 30 J of work?
-120 J (heat lost)

5. Suppose a woman does 500 J of work and 9500 J of heat transfer occurs into the environment in the process. (a) What is the decrease in her internal energy, assuming no change in temperature or consumption of food? (b) What is her efficiency?
-10,000 J, 5%

14. Calculate the net work output of a heat engine following path ABCDA in the figure below. 4.5 kJ

15. What is the net work output of a heat engine that follows path ABDA in the figure above. 2.4 kJ

54. Find the increase in entropy of 1 kg of liquid nitrogen that starts at its boiling temperature, boils, and warms to 20°C at constant pressure. T=-195.8°C, Lv= 201 J/g, cp=1.04 J/g K
S=1000*201/(273.15-195.8)= 2599 J/K (for boil)
1000*1.04*(20+195.8)/(273.15+(20-195.8)/2)= 1212 J/K (book)
1000*1.04*ln((273.15+20)/(273.15-195.8)) = 1386 J/K (TK)

52. (a) In reaching equilibrium, how much heat transfer occurs from 1 kg of water at 40°C when it is placed in contact with 1 kg of 20°C water in reaching equilibrium? (b) What is the change in entropy due to this heat transfer? (c) How much work is made unavailable, taking the lowest temperature to be 20°C ?
Tf=30°C; Q=1000*4.186*10=41.9 kJ
m c (ln((To+30)/(To+40))+ln((To+30)/(To+20)))=4.56 J/K

28. A certain gasoline engine has an efficiency of 30%. What would the hot reservoir temperature be for a Carnot engine having that efficiency, if it operates with a cold reservoir temperature of 200°C? 676 K

33. A coal-fired electrical power station has an efficiency of 38%. The temperature of the steam leaving the boiler is 550°C . What percentage of the maximum efficiency does this station obtain? (Assume the temperature of the environment is 20°C .) 59%

40. In a very mild winter climate, a heat pump has heat transfer from an environment at 5°C to one at 35°C . What is the best possible coefficient of performance for these temperatures? COP=10.3

42. (a) What is the best coefficient of performance for a refrigerator that cools an environment at -30°C and has heat transfer to another environment at 45°C ? (b) How much work in joules must be done for a heat transfer of 4186 kJ from the cold environment? (c) What is the cost of doing this if the work costs 10.0 cents per 3.6e6 J (a kilowatt-hour)? (d) How many kJ of heat transfer occurs into the warm environment?

COP=3.24; W=4186 kJ/COP=1.29e6 J, 3.6cents, 5.48e6 J

47. (a) On a winter day, a certain house loses 5e8 J of heat to the outside (about 500,000 Btu). What is the total change in entropy due to this heat transfer alone, assuming an average indoor temperature of 21°C and an average outdoor temperature of 5°C ?

5e8(-1/(273+21)+1/(273+5))=9.79e4 J/K

55. A large electrical power station generates 1000 MW of electricity with an efficiency of 35%. (a) Calculate the heat transfer to the power station, Qh, in one day. (b) How much heat transfer Qc occurs to the environment in one day? (c) If heat transfer in the cooling towers is from 35°C water into the local air mass, which increases in temperature from 18°C to 20°C, what is the total increase in entropy due to this heat transfer? (d) How much energy becomes unavailable to do work because of this increase in entropy, assuming an 18°C lowest temperature? (Part of Qc could be utilized to operate heat engines or for simply heating the surroundings, but it rarely is.)

Qh=(1000e6*24*3600)/.35 = 2.47e14 J; Qc=Qh-(1000e6*24*3600)

ΔS=Qc*(1/(273+19)-1/(273+35))=2.86e10 J/K

W= S*(273+18)=8.31e12 J

old exam #15

A: (4452-2828) kJ = 1624 kJ

B: 10e6*(.06789-.01803)=499 kJ

C: Q = ΔU+W=(4452-2545)kJ+499 kJ=2406 kJ

D: Q=(273+311)*(5.6159-8.2124)=-1514 kJ

59. (a) If tossing 100 coins, how many ways (microstates) are there to get the three most likely macrostates of 49 heads and 51 tails, 50 heads and 50 tails, and 51 heads and 49 tails? (b) What percent of the total possibilities is this? (Consult Table15.4.) 24%

60. (a) What is the change in entropy if you start with 100 coins in the 45 heads and 55 tails macrostate, toss them, and get 51 heads and 49 tails? (b) What if you get 75 heads and 25 tails? (c) How much more likely is 51 heads and 49 tails than 75 heads and 25 tails? (d) Does either outcome violate the second law of thermodynamics?

k ln(9.9e28/6.1e28), k ln(2.4e23/6.1e28), 9.9e28/2.4e23, NO