AP Physics 2 Summer Assignment
Dwight Morrow High School & Academies @ Englewood
2018 - 2019

Welcome to AP Physics 2; this coming year we will build on all your prior physics knowledge by applying and extending it in various areas of physics.

It is imperative that you complete **all** work in a timely manner. We will move faster than you are used to, and I expect a great deal from you.
If you begin to fall behind or are having trouble, it is essential to make time to see me about it. We will set a tutorial hour the first week of class.

This assignment will take you time. Do not wait until the last week to complete it. It will count as a test grade, a lab grade, and set you up for success in the course.

Do not languish on a question. If you find something difficult, attempt to solve it (show some ORGANIZED work) then move on. Return to it later (at least 10 minutes) and try again. If you need help, talk to your peers first, then if the issue persists, send me an email jsloane@epsd.org

Step 1: Read the course policies page.
Step 2: Complete the vectors unit on Khan Academy. Take screenshots of each quiz and test.
I recommend that you do the practice for yourself.
You will use vectors all year; many physical quantities are vector quantities.
Step 3: Complete the Khan Academy unit on fluids and thermodynamics.
Step 4: Complete the attached questions on fluids and thermodynamics.
Step 5: Complete the lab.

On the first day of class, you should have:

- A binder (strongly recommended) or notebook dedicated to physics.
- A pen (and a pencil if you like).
- Screenshot of your completed Khan academy work
  - Vectors Quizzes
  - Fluid mechanics pages showing completion
  - Thermodynamics pages showing completion
- Completed fluid mechanics and thermodynamics work.
- Your lab notes – in pen.
- Your completed lab write up.

Course Policies

Responsibility

We are in an AP Class, I expect you to be responsible for yourself and your learning.
We will all respect each other and our learning; this means that class time is for physics.
Everyone experiences the world we are studying, we all have valid viewpoints- some of us bring more practical experience, others bring more mathematical ability, still others bring an intuition. Your contribution is valuable. We will all be wrong at some point in class - including me (please correct me! I'm human and make mistakes).

Class Requirements

You should have a space set aside for physics. You need to bring a binder and pen everyday.
Your notes should be kept in the binder, worksheets and quizzes should be added to it.
You should make a note of when a lab is completed. **Each sheet should be dated**.

Cheating vs Collaboration

Collaboration is when students work together to get the idea of how to approach a problem and then write up their problem separately. Collaboration includes attribution - you should state your collaborators names after your own.

Cheating and collaboration are separate things. There will be assignments where I allow collaboration. Laboratory assignments should almost always be collaborative. Lab reports will be longer assignments and require you to think carefully as well as present your ideas clearly. **Each student is responsible for knowledge of the entire lab.**

Lab Scenario:
Student A writes the introduction, and student B the procedure. They then edit the other's work for correctness, clarity, and cohesiveness. I should not be able to tell that one student made the first draft of a given section. The entire lab should look like the work of a cohesive group. **Each student is responsible for the entire lab,** however one lab report per lab **pair** is acceptable.

Cheating, i.e. sharing homework, lab work, exam answers etc., will earn all parties a zero for the assignment along with referral to the office pursuant to district policy. Cheating on collaborative assignments is, for example, if two lab groups turn in identical copies of a lab report with different names on them.

Lab Policy

Researchers keep a notebook that is a day to day record of what they do, why they do it, and any issues that arise or odd things that are noticed. These odd things are usually the most important. They become central to the analysis or point to new ideas. In the research world, it is usually "huh?" that indicates a discovery.

The lab notebook will be your set of notes from before, during, and after the lab. These notes should be neat, you will need to reference them later. These notes will be useful when you type your lab report. **Your lab report will be submitted as a pdf**, but can be written in your choice of program. I recommend Google Docs, Microsoft Office, Libre Office, or LaTeX (all of these should be free for you). Microsoft through the district, and the others are funded by advertising (google) or are community developed open source projects. If you would like help in getting these to work, please talk to me after class. LaTeX is likely what you'll use if you go into a field requiring typesetting of equations (research physics or mathematics) though it does have a steeper learning curve.

Rubrics will be given out on the first day of class.
Labs will be graded according to the rubric. Notably, late lab reports will be penalized by 10% per day - including weekend days because they are submitted electronically.

Homework Policy

You will have homework nearly every day. The length of homework will vary. Often it will be between one and three mandatory problems and several optional problems. If you get the mandatory problems wrong, you may move on to the optional work to improve your grade.

Your homework should have a header. It will be worth 5% of each HW. At the top of the page:

Your Name	Date Work Done
Physics : Unit (Kinematics etc)	Assignment

Quizzes
On non-lab days, we will have a do now in the first three minutes and an exit question in the last five. These will form a quiz grade each week. The do-now will generally be a primer for the day's work. The exit question will generally be about the day's work.
Approximately ten points each week of quiz grades.

Tests
Tests will mimic the AP Test in format and difficulty and will be at the end of each unit.

We will cover: Fluid Mechanics, Thermodynamics, Electrostatics, Circuitry, Magnetism, Optics, Modern Physics. The full syllabus will be handed out on the first day.

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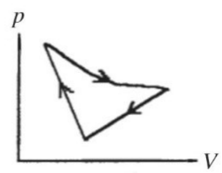
Summer Problems

Part 1 Thermodynamics (Conceptual)

1. A certain gas is compressed adiabatically. The amount of work done on the gas is 800 J. What is the change in the internal (thermal) energy of the gas?

A) 800 J B) -800 J C) 400 J D) 0 J
E) More information is needed to answer this question.

2. A cyclic process is carried out on an ideal gas such that it returns to its initial state at the end of a cycle, as shown in the *pV* diagram in the figure. If the process is carried out in a clockwise sense around the enclosed area, as shown on the figure, then the change of internal energy over the full cycle



A) is positive. B) is negative. C) is zero. D) cannot be determined from the information given.

3. Which one of the following is a *true* statement?
A) The second law of thermodynamics is a consequence of the first law of thermodynamics.
B) It is possible for heat to flow spontaneously from a hot body to a cold one or from a cold one to a hot one, depending on whether or not the process is reversible or irreversible.
C) It is not possible to convert work entirely into heat.
D) It is impossible to transfer heat from a cooler to a hotter body.
E) All of these statements are false.

4. Define and explain the Carnot cycle:.

5. If the efficiency of a Carnot engine were to be 100%, the heat sink would have to be

A) at absolute zero. B) at 0°C. C) at 100°C. D) infinitely hot.

6. An important feature of the Carnot cycle is that

A) its efficiency can be 100%.
B) its efficiency depends only on the absolute temperature of the hot reservoir used.
C) its efficiency is determined by the temperatures of the hot and cold reservoirs between which it works and by the properties of the working substance used, and on nothing else.
D) it is an example of an irreversible process that can be analyzed exactly without approximations.
E) no engine can be more efficient than a Carnot engine operating between the same two temperatures.

7. An ideal gas undergoes an isothermal expansion. During this process, its entropy
   A) decreases.
   B) remains unchanged.
   C) increases.
   D) cannot be predicted from the data given.

8. Two metal spheres are made of the same material and have the same diameter, but one is solid and the other is hollow. If their temperature is increased by the same amount,

   A) the solid sphere becomes bigger than the hollow one.
   B) the hollow sphere becomes bigger than the solid one.
   C) the two spheres remain of equal size.
   D) the solid sphere becomes denser and the hollow one less dense.
   E) the solid sphere becomes less dense and the hollow one denser.

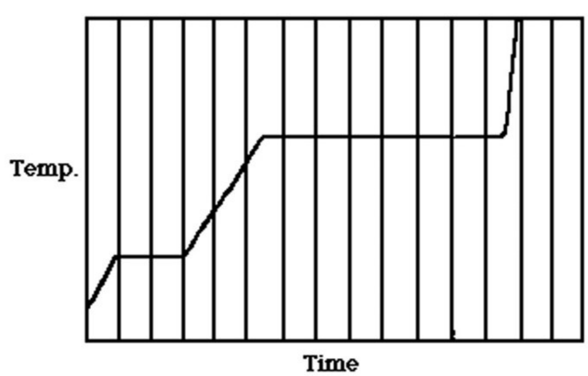
9. If you wanted to know how much the temperature of a particular piece of material would rise when a known amount of heat was added to it, which of the following quantities would be most helpful to know?

   A) initial temperature B) specific heat C) density
   D) coefficient of linear expansion E) thermal conductivity

10. Which one of the following quantities is the *smallest* unit of heat energy?

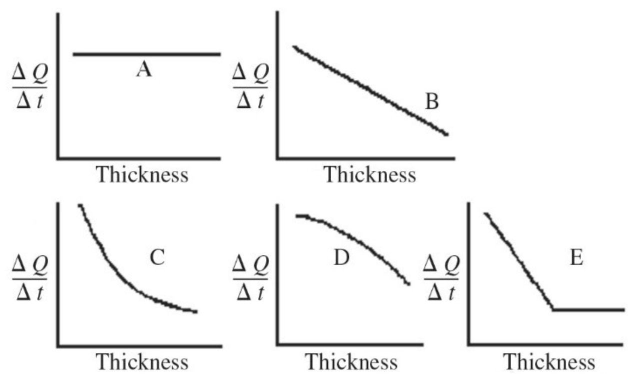
    A) calorie B) kilocalorie C) Btu D) joule

11. The figure shows a graph of the temperature of a pure substance as a function of time as heat is added to it at a constant rate in a closed container. If L_F is the latent heat of fusion of this substance and L_V is its latent heat of vaporization, what is the value of the ratio L_V/L_F?



    A) 5.0 B) 4.5 C) 7.2 D) 3.5 E) 1.5

12. An architect is interested in estimating the rate of heat loss, $\Delta Q/\Delta t$, through a sheet of insulating material as a function of the thickness of the sheet. Assuming fixed temperatures on the two faces of the sheet and steady state heat flow, which one of the graphs shown in the figure best represents the rate of heat transfer as a function of the thickness of the insulating sheet?



A) A B) B C) C D) D E) E

13. If, with steady state heat flow established, you double the thickness of a wall built from solid uniform material, the rate of heat loss for a given temperature difference across the thickness will

A) become one-half its original value. B) also, double. C) become one-fourth its original value. D) become $1/\sqrt{2}$ of its original value. E) become four times its original value.

14. An object having a fixed emissivity of 0.725 radiates heat at a rate of 10 W when it is at an absolute temperature T. If its temperature is doubled to $2T$, at what rate will it now radiate?

A) 20 WB) 40 W C) 80 W D) 160 W E) 320 W

15. Two containers of equal volume each hold samples of the same ideal gas. Container A has twice as many molecules as container B. If the gas pressure is the same in the two containers, the correct statement regarding the absolute temperatures T_A and T_B in containers A and B, respectively, is

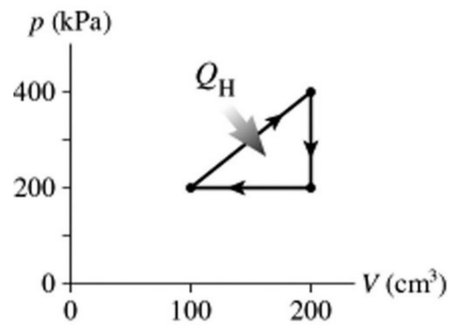
A) $T_A = T_B$. B) $T_A = 2T_B$. C) $T_A = \frac{1}{2}T_B$. D) $T_A = \frac{1}{\sqrt{2}}T_B$.

E) $T_A = \frac{1}{4}T_B$.

16. A mole of diatomic oxygen molecules and a mole of diatomic nitrogen molecules are at STP. Which statements are true about these molecules? (There could be more than one correct choice.)

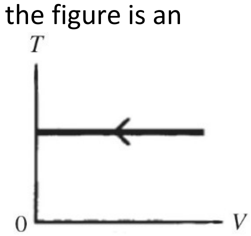
    A) Both gases have the same average molecular speeds.
    B) Both gases have the same number of molecules.
    C) Both gases have the same average kinetic energy per molecule.
    D) Both gases have the same average momentum per molecule.

17. The figure shows a *pV* diagram for a cycle of a heat engine for which Q_H = 59 J. What is the thermal efficiency of the engine?



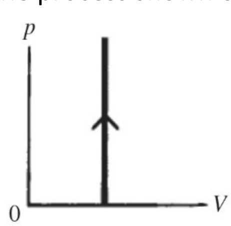
    A) 17% B) 34% C) 8.5% D) 14%

18. The process shown on the *TV* graph in the figure is an



    A) Adiabatic compression. B) Isothermal compression.
    C) Isochoric compression. D) Isobaric compression.

19. The process shown on the *pV* diagram in the figure is



    A) Adiabatic. B) Isothermal. C) Isochoric. D) Isobaric.

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Part 2 Thermodynamics Problems

1. Express a body temperature 98.6°F in Celsius degrees.

   A) 37.0°C B) 45.5°C C) 66.6°C D) 72.6°C

2. At what, if any, temperature are the numerical readings on the Fahrenheit and Celsius scales the same?

   A) -30° B) -40° C) -50° D) -60°
   E) They can never read the same because they are based on different zeroes.

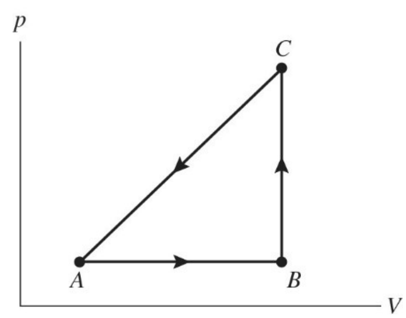
3. A person running in place on an exercise machine for 10 min uses up 17 kcal (food calories). Another person exercises by repeatedly lifting two 2.5-kg weights a distance of 50 cm. How many repetitions of this exercise are equivalent to 10 minutes of running in place? Assume that the person uses negligible energy in letting down the weights after each lift. (1 cal = 4.186 J)

   A) 730 B) 1450 C) 1500 D) 2200 E) 2900

4. A monatomic ideal gas undergoes an isothermal expansion at 300 K, as the volume increased from 0.010 m^3 to 0.040 m^3. The final pressure is 130 kPa. What is the change in the internal (thermal) energy of the gas during this process? (R = 8.31 J/mol · K)

   A) 0.0 kJ B) 3.6 kJ C) 7.2 kJ D) -3.6 kJ E) -7.2 kJ

5. The figure shows a pV diagram for a gas going through a cycle from A to B to C and back to A. From point A to point B, the gas absorbs 50 J of heat and finds its internal (thermal) energy has increased by 20 J. Going from B to C, the internal (thermal) energy decreases by 5.0 J.



   (a) How much work was done by the gas from A to B?
   (b) How much heat was absorbed by the gas from B to C?
   (c) How much work was done by the gas going from B to C?

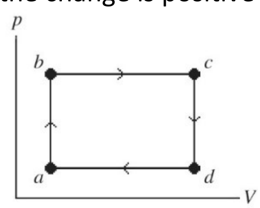
6. During an isothermal process, 5.0 J of heat is removed from an ideal gas. What is the work done by the gas in the process?
   A) 0 J B) 5.0 J C) -5.0 J D) -10 J

7. In an adiabatic compression, 200 J of work is done on a gas. What is the change in internal (thermal) energy of the gas during this compression?

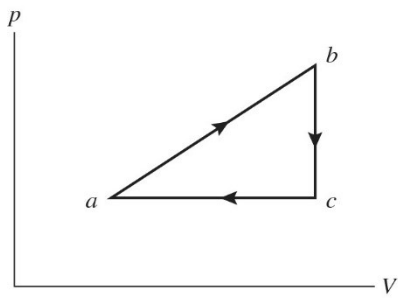
8. An ideal gas undergoes an adiabatic process while doing 25 J of work. What is the change in the internal (thermal) energy of the gas?

9. A fixed amount of an ideal monatomic gas is maintained at constant volume as it is cooled by 50 K. This feat is accomplished by removing 400 J of energy from the gas. How much work is done by the gas during this process?
A) 0 J B) 400 J C) -400 J D) -200 J

10. The figure shows a *pV* diagram of a gas for a complete cycle. During part *bc* of the cycle, 1190 J of heat flows into a system, and at the same time the system expands against a constant external pressure of 7.00×10^4 Pa as its volume increases from $0.0200\ \mathrm{m}^3$ to $0.0800\ \mathrm{m}^3$. Calculate the change in internal (thermal) energy of the system during part *bc* of the cycle. If the change is nonzero, be sure to indicate whether the change is positive or negative.



11. An ideal gas undergoes the process *a*→*b*→*c*→*a* shown in the *pV* diagram. In the figure, $P_a = P_c$ = 240 kPa, $V_b = V_c$ = 40 L, V_a = 15 L, and P_b = 400 kPa. How much heat is gained by the gas in this *a*→*b*→*c*→*a* process?



12. A heat engine absorbs 64 kcal of heat each cycle and exhausts 42 kcal.
(a) What is the efficiency of this engine?
(b) How much work does this engine do per cycle?

13. A heat engine absorbs 85.6 kJ of heat each cycle and exhausts 61.8 kJ.
(a) What is the efficiency of the engine?
(b) How much work does it do each cycle?

14. The coefficient of linear expansion of steel is 12×10^{-6} K^{-1}. What is the change in length of a 25-m steel bridge span when it undergoes a temperature change of 40 K from winter to summer?
A) 1.2 cm B) 1.4 cm C) 1.6 cm D) 1.8 cm E) 2.0 cm

15. By what length will a slab of concrete that is originally 18 m long contract when the temperature drops from 24°C to -16°C? The coefficient of linear thermal expansion for this concrete is 1.0×10^{-5} K^{-1}.
A) 0.50 cm B) 0.72 cm C) 1.2 cm D) 1.5 cm

16. A quantity of mercury occupies 400.0 cm^3 at 0°C. What volume will it occupy when heated to 50°C? Mercury has a volume expansion coefficient of 180×10^{-6} K^{-1}.
A) 450 cm^3 B) 409.7 cm^3 C) 403.6 cm^3 D) 401.8 cm^3

17. The volume coefficient of thermal expansion for gasoline is 950×10^{-6} K^{-1}. By how many cubic centimeters does the volume of 1.00 L of gasoline change when the temperature rises from 30°C to 50°C?

18. Suppose that a rigid aluminum wire were to be strung out in a loop that just fits snugly around the equator (assuming a perfectly spherical Earth with a radius of 6.37×10^6 m). If the temperature of the wire is increased by 0.50°C, and the increase in length is distributed equally over the entire length, how far off the ground will the wire loop be if it remained centered on the earth? The coefficient of linear expansion of aluminum is 24×10^{-6} K^{-1}.

19. The coefficient of linear expansion of copper is 17×10^{-6} K^{-1} and that of steel is 12×10^{-6} K^{-1}. At 12°C a steel rod has a diameter of 2.540 cm and a copper pipe has a diameter of 2.536 cm. Which one of the following quantities is closest to the temperature to which the copper pipe must be heated in order for the unheated steel rod to fit snugly in the copper pipe?
A) 53°C B) 81°C C) 93°C D) 105°C E) 143°C

20. An aluminum electric tea kettle with a mass of 500 g is heated with a 500-W heating coil. How long will it take to heat up 1.0 kg of water from 18°C to 98°C in the tea kettle? The specific heat of aluminum is 900 J/kg · K and that of water is 4186 J/kg · K.
A) 5.0 minutes B) 7.0 minutes C) 12 minutes D) 15 minutes E) 18 minutes

21. In grinding a steel knife, the metal can get as hot as 400°C. If the blade has a mass of 80 g, what is the minimum amount of water needed at 20°C if the water is to remain liquid and not rise above 100°C when the hot blade is quenched in it? The specific heat of the steel is 0.11 cal/g · C° and the specific heat of water is 1.0 cal/g · C°.
A) 22 g B) 33 g C) 44 g D) 55 g

22. If you add 700 kJ of heat to 700 g of water originally at 70.0°C, how much water is left in the container? The latent heat of vaporization of water is 22.6 × 10^5 J/kg, and its specific heat capacity is 4186 J/kg · K.
A) 429 g B) 258 g C) 340 g D) 600 g E) none

23. A 2294-kg sample of water at 0° C is cooled to –36° C, and freezes in the process. How much heat is liberated? For water L_F = 334,000 J/kg and L_V = 2.256 × 10^6 J/kg. The specific heat of ice is 2050 J/kg · K.

24. A person makes iced tea by adding ice to 1.8 kg of hot tea, initially at 80°C. How many kilograms of ice, initially at 0°C, are required to bring the mixture to 10°C? The specific heat of water (and tea) is 4186 J/kg · K, and the latent heat of fusion of ice is 3.34 × 10^5 J/kg.
A) 1.0 kg B) 1.2 kg C) 1.4 kg D) 1.7 kg

25. A 400-g block of iron at 400°C is dropped into a calorimeter (of negligible heat capacity) containing 60 g of water at 30°C. How much steam is produced? The latent heat of vaporization of water is 22.6 × 10^5 J/kg and its specific heat capacity is 4186 J/kg · K. The average specific heat of iron over this temperature range is 560 J/kg · K.
A) 22 g B) 33 g C) 42 g D) 54 g E) 59 g

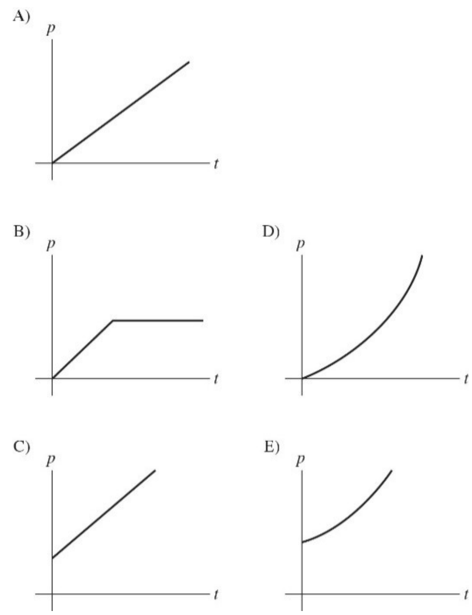
Part 3: Fluid Conceptual

1. A hollow sphere of negligible mass and radius R is completely filled with a liquid so that its density is ρ. You now enlarge the sphere so its radius is $2R$ and completely fill it with the same liquid. What is the density of the enlarged sphere?
A) 8 ρ B) 4 ρ C) $\rho/2$ D) ρ E) $\rho/8$

2. When a box rests on a round sheet of wood on the ground, it exerts an average pressure p on the wood. If the wood is replaced by a sheet that has half the diameter of the original piece, what is the new average pressure?
A) $4p$ B) $2p$ C) $p\sqrt{2}$ D) $p/2$ E) $p/4$

3. When a heavy metal block is supported by a cylindrical vertical post of radius R, it exerts a force F on the post. If the diameter of the post is increased to $2R$, what force does the block now exert on the post?
A) $F/4$ B) $F/2$ C) $F/\sqrt{2}$ D) F E) $2F$

4. A cubical block of stone is lowered at a steady rate into the ocean by a crane, always keeping the top and bottom faces horizontal. Which one of the following graphs best describes the gauge pressure p on the bottom of this block as a function of time t if the block just enters the water at time $t = 0$ s?



5. A spherical ball of lead (density 11.3 g/cm^3) is placed in a tub of mercury (density 13.6 g/cm^3). Which answer best describes the result?
A) The lead ball will float with about 83% of its volume above the surface of the mercury.
B) The lead ball will float with its top exactly even with the surface of the mercury.
C) The lead ball will float with about 17% of its volume above the surface of the mercury.
D) The lead will sink to the bottom of the mercury

6. A boat loaded with rocks is floating in a swimming pool. If the rocks are thrown into the pool, the water level in the pool, after the rocks have settled to the bottom,
   A) rises. B) falls. C) stays the same.
7. A piece of iron rests on top of a piece of wood floating in a bathtub. If the iron is removed from the wood, and kept out of the water, what happens to the water level in the tub?

   A) It goes up.
   B) It goes down.
   C) It does not change.
   D) It is impossible to determine from the information given.

8. A 50-cm^3 block of wood is floating on water, and a 50-cm^3 chunk of iron is totally submerged in the water. Which one has the greater buoyant force on it?

A) the wood
B) the iron
C) Both have the same buoyant force.
D) It cannot be determined without knowing their densities.

Part 4: Fluid Problems:

1. A plastic block of dimensions 2.00 cm × 3.00 cm × 4.00 cm has a mass of 30.0 g. What is its density?

   A) 0.80 g/cm^3 B) 1.20 g/cm^3 C) 1.25 g/cm^3 D) 1.60 g/cm^3

2. Under standard conditions, the density of air is 1.29 kg/m^3. What is the mass of the air inside a room measuring 4.0 m × 3.0 m × 2.0 m?

3. How many grams of ethanol (density 0.80 g/cm^3) should be added to 5.0 g of chloroform (density 1.5 g/cm^3) if the resulting mixture is to have a density of 1.2 g/cm^3? Assume that the fluids do not change their volumes when they are mixed.

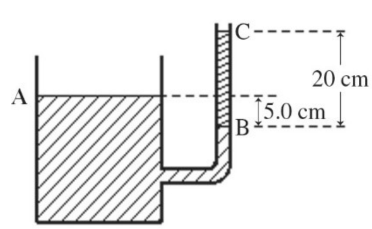
   A) 2.0 g B) 2.4 g C) 1.8 g D) 4.4 g E) 1.6 g

4. Calculate the pressure exerted on the ground due to the weight of a 79-kg person standing on one foot. if the bottom of the person's foot is 13 cm wide and 28 cm long.

5. What force does the water exert (in addition to that due to atmospheric pressure) on a submarine window of radius 44.0 cm at a depth of 9400 m in sea water? The density of sea water is 1025 kg/m^3.

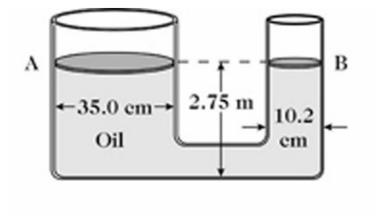
   A) 5.74×10^7 N B) 5.74×10^{11} N C) 2.87×10^{11} N D) 1.83×10^7 N E) 2.87×10^7 N

6. A container has a vertical tube, whose inner radius is 24.00 mm, connected to it at its side, as shown in the figure. An unknown liquid reaches level A in the container and level B in the tube–level A being 5.0 cm higher than level B. The liquid supports a 20-cm high column of oil, between levels B and C, whose density is 570 kg/m^3. The mass of the oil is closest to



   A) 210 B) 410 C) 620 D) 820 E) 1000

7. A container consists of two vertical cylindrical columns of different diameter connected by a narrow horizontal section, as shown in the figure. The open faces of the two columns are closed by very light plates that can move up and down without friction. The tube diameter at *A* is 35.0 cm and at *B* it is 10.2 cm. This container is filled with oil of density 0.820 g/cm^3. If a 125-kg object is placed on the larger plate at *A*, how much mass should be placed on the smaller plate at *B* to balance it?



8. A 13,000-N vehicle is to be lifted by a 25-cm diameter hydraulic piston. What force needs to be applied to a 5.0 cm diameter piston to accomplish this? Assume the pistons each have negligible weight.
9. An object has a volume of 4.0 m^3 and weighs 40,000 N. What will its apparent weight be in water of density 1000 kg/m^3?

   A) 40,000 N B) 39,200 N C) 9,800 N D) 800 N
10. A solid object floats in water with three-fourths of its volume beneath the surface. What is the object's density? The density of water is 1000 kg/m^3.

    A) 1333 kg/m^3 B) 1000 kg/m^3 C) 750 kg/m^3 D) 250 kg/m^3

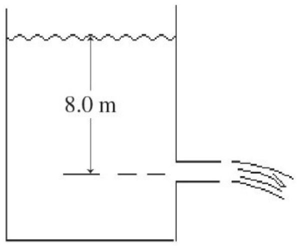
11. A wooden raft has a mass of 55 kg. When empty it floats in water (density 1000 kg/m^3) with 64% of its volume submerged. What maximum mass of sand can be put on the raft without sinking it?

12. Consider a very small hole in the bottom of a tank that is 17.0 cm in diameter and filled with water to a height of 90.0 cm. Find the speed at which the water exits the tank through the hole.
    A) 4.20 m/s B) 17.64 m/s C) 44.1 m/s D) 48.3 m/s
13. Fluid flows at 2.0 m/s through a pipe of diameter 3.0 cm. What is the volume flow rate of the fluid?

    A) 1.4×10^{-3} m^3/s B) 5.7×10^{-3} m^3/s C) 14 m^3/s D) 57 m^3/s
14. An ideal incompressible fluid flows at 0.252 m/s through a 44-mm diameter cylindrical pipe. The pipe widens to a *square* cross sectional area that is 5.5 cm on a side. Assume steady flow throughout the system.

    (a) What is the speed of the fluid through the square section of pipe?
    (b) What is the flow rate in liters per minute?

15. Water flows out of a large reservoir through an open pipe, as shown in the figure. What is the speed of the water as it comes out of the pipe?



A) 8.9 m/s B) 9.9 m/s C) 13 m/s D) 14 m/s E) 16 m/s

Summer Lab

Please do NOT spend money to complete this lab. If you are having difficulty, contact me.

This lab is to be a testing experiment regarding the continuity equation from fluid dynamics. It is also an exercise in experimental design. Some of our labs this coming year will be similar, some different. You may work with a single partner (who also is in AP Physics 2) on this lab; in this case you must both be present for the experiment and share fully in the data collection and analysis.

On the first day of class, bring a write-up of the experiment you designed. If you work in pairs, each of you must bring a copy of the write-up. Notes taken during the experiment should be in pen and original copies (even if messy) should be retained. If they are illegible please also recopy.

Prompt:

One of your colleagues has expressed a new idea while researching fluid behavior. They describe their idea as a continuity equation[1]. They say that when fluid flows out of a region, its speed will depend on the speed of the inflowing fluid and the size of the both the inflowing and outflowing opening. They further express this as an equation relating the velocity of the fluid and the area of the opening the fluid goes through as : $A_{in}v_{in} = A_{out}v_{out}$.

Design – Complete this section fully before doing the experiment.

Design an experiment that tests the continuity equation using :

- A ruler
- Tape
- Water
- A timer (a phone works fine here, and you can use video if you'd like)
- A Cardboard box (such as a cereal box to direct water)
- Scissors (you should cut the box to change its shape)
- A leaf (broken into pieces) / black pepper / paper / anything small & visible which floats
- A container / cup / pot to be your water source.

Make sure you describe the experimental set-up in enough detail that someone else can reproduce it without speaking to you about it. Diagrams can be very helpful here.

What data will you directly measure?
What adds uncertainty to your measurements?

What will you calculate?
How does the uncertainty influence your calculations?
From your data, what do you expect to conclude about the continuity equation of fluid dynamics?

[1] Why do we use this phrase? What do we mean by a continuity equation? (Use your own words.)

Experiment – Complete this after fully completing the design.

Carry out the experiment as you designed it. If you need to modify your design, make a note of why. Record your data clearly, in a labelled chart. As you carry out the experiment, make notes about anything that doesn't go as planned AND anything that might impact your data.
Show any calculations you make.

What can you conclude from your experiment?

How might you change your experiment (without adding technology / increasing your budget) to improve the certainty of your conclusion?