General physics review

You can use on the exam:

a **cheat sheet**.

- One piece of paper, both sides
- Write anything you want
- Must be hand written **by you** (cannot borrow or photocopy a friend's cheat sheet)

Anthony and Sissy are participating in the "Roll-a-Rama" rollerskating dance championship. While 75.0-kg Anthony rollerskates backwards at 3.0 m/s, 60.0-kg Sissy jumps into his arms with a velocity of 5.0 m/s in the same direction. a) How fast does the pair roll backwards together? b) If Anthony is skating toward Sissy when she jumps, would their combined final velocity be larger or smaller than your answer to part a? Why?

To test the strength of a retainment wall designed to protect a nuclear reactor, a rocket-propelled F-4 Phantom jet aircraft was crashed head-on into a concrete barrier at high speed in Sandia, New Mexico on April 19, 1988. The F-4 phantom had a mass of 19100 kg, while the retainment wall's mass was 469000 kg. The wall sat on a cushion of air that allowed it to move during impact. If the wall and F-4 moved together at 8.41 m/s during the collision, what was the initial speed of the F-4 Phantom?

inelastic collision

Known

Want

Know: m_w, m_A, V_f

Want: V_0

$p_0 = p_f$

$p_0 = m_A V_0 + m_w V_{0w}$

$p_f = (m_A + m_w) V_f$

$p_0 = 19100\,kg \cdot V_0$

$p_f = (469000\,kg + 19100\,kg)\, 8.41 \frac{m}{s}$

$p_0 = p_f$

$19100\,kg \cdot V_0 = (469{,}000\,kg + 19{,}100\,kg)\, 8.41 \frac{m}{s}$

$19100\,kg\, V_0 = 488{,}100\,kg \cdot 8.41 \frac{m}{s}$

$19{,}100\,kg\, V_0 = 4{,}104{,}921\,kg \cdot \frac{m}{s}$ ÷ 19,100 kg

$V_0 = 215 \frac{m}{s}$

Valentina, the Russian Cosmonaut, goes outside her ship for a spacewalk, but when she is floating 15 m from the ship, her tether catches on a sharp piece of metal and is severed. Valentina tosses her 2.0-kg camera away from the spaceship with a speed of 12 m/s. a) How fast will Valentina, whose mass is now 68 kg, travel toward the spaceship? b) Assuming the spaceship remains at rest with respect to Valentina, how long will it take her to reach the ship?

A 620.-kg moose stands in the middle of the railroad tracks, frozen by the lights of an oncoming 10 000.-kg locomotive that is traveling at 10.0 m/s. The engineer sees the moose but is unable to stop the train in time and the moose rides down the track sitting on the cowcatcher. What is the new combined velocity of the locomotive and the moose?

$M_0 V_{0+} M_1 V_1 =$

$M_0 V_{f0} + M_1 V_{f1}$

$P_0 = P_f$

$620\text{kg} \cdot 0 + 10{,}000\text{kg} \cdot 10\frac{m}{s} = (620\text{kg} + 10{,}000\text{kg}) V_f$

Lee is rolling along on her 4.0-kg skateboard with a constant speed of 3.0 m/s when she jumps off the back and continues forward with a velocity of 2.0 m/s relative to the ground. This causes the skateboard to go flying forward with a speed of 15.5 m/s relative to the ground. What is Lee's mass?

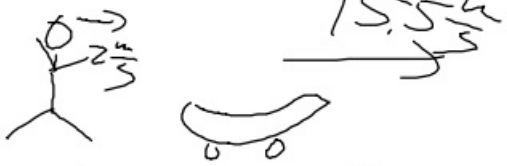
V_{BS}, V_{fL}

Know: M_B, V_0

Want: M_L

Initial

Final



$$KE_0 = \frac{1}{2}4kg\left(3\frac{m}{s}\right)^2 + \frac{1}{2}M_L\left(3\frac{m}{s}\right)^2$$

18 $\quad \frac{9}{2}M$

$$KE_f = \frac{1}{2}\cdot 4kg\cdot\left(15.5\frac{m}{s}\right)^2 + \frac{1}{2}M_L\left(2\frac{m}{s}\right)^2$$

480.5 $\quad 2M$

$$KE_0 = KE_f$$

$$\left[18J + \frac{9}{2}M = 480.5J + 2M\right] - 2M$$

$$\left[18J + 2.5\frac{m^2}{s^2}M = 480.5J\right] - 18J$$

$$+2.5\frac{m^2}{s^2}M = 462.5J$$

$$M = +185kg$$

$$E_0 + W = E_f$$

W

Fd

Lee is rolling along on her 4.0-kg skateboard with a constant speed of 3.0 m/s when she jumps off the back and continues forward with a velocity of 2.0 m/s relative to the ground. This causes the skateboard to go flying forward with a speed of 15.5 m/s relative to the ground. What is Lee's mass?

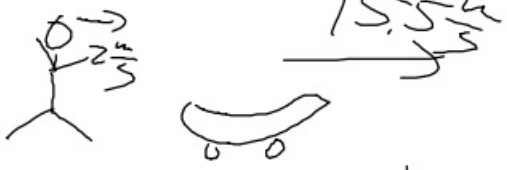
V_{BS}, V_{fL}

Know: M_s, V_0

Want: M_L

Initial

Final



$$p_0 = 4kg\,3\tfrac{m}{s} + M \cdot 3\tfrac{m}{s}$$

$12kg\tfrac{m}{s} + 3\tfrac{m}{s}M$

$$p_f = 4kg \cdot 15.5\tfrac{m}{s} + M \cdot 2\tfrac{m}{s}$$

$62kg\tfrac{m}{s} + 2\tfrac{m}{s} \cdot M$

$$p_0 = p_f$$

$$12kg\tfrac{m}{s} + 3\tfrac{m}{s}M = 62kg\tfrac{m}{s} + 2\tfrac{m}{s}M \quad -2M$$

$$12 + M1\tfrac{m}{s} = 62kg\tfrac{m}{s} \quad -12$$

$$M \cdot 1\tfrac{m}{s} = 50kg\tfrac{m}{s}$$

$$E_0 + W = E_f$$

$$Fd$$

A-1: Bernie, whose mass is 70.0 kg, leaves a ski jump with a velocity of 21.0 m/s. What is Bernie's momentum as he leaves the ski jump?

A-2: Ethel is sitting on a park bench feeding the pigeons when a child's ball rolls toward her across the grass. Ethel returns the ball to the child by hitting it with her 2.0-kg pocketbook with a speed of 20 m/s. If the impact lasts for 0.4 s, with what force does Ethel hit the ball?

A-3: When Reggie stepped up to the plate and hit a 0.150-kg fast ball traveling at 36.0 m/s, the impact caused the ball to leave his bat with a velocity of 45.0 m/s in the opposite direction. If the impact lasted for 0.002 s, what force did Reggie exert on the baseball?

A-10: Miguel, the 72.0-kg bullfighter, runs toward an angry bull at a speed of 4.00 m/s. The 550.-kg bull charges toward Miguel at 12.0 m/s and Miguel must jump on the bull's back at the last minute to avoid being run over. What is the new velocity of Miguel and the bull as they move across the arena?

A-12: The U.S.S. *Constitution,* the oldest fully commissioned war ship in the world, is docked in Boston, Massachusetts. Also known as "Old Ironsides" for her seemingly impenetrable hull, the frigate houses 56 pieces of heavy artillery. Mounted on bearings that allow them to recoil at a speed of 1.30 m/s are 20 carronades, each with a mass of 1000. kg. If a carronade fires a 14.5-kg cannonball straight ahead, with what muzzle velocity does the cannonball leave the cannon?

Exercise 1: On his way off to college, Russell drags his suitcase 15.0 m from the door of his house to the car at a constant speed with a horizontal force of 95.0 N. a) How much work does Russell do to overcome the force of friction? b) If the floor has just been waxed, does he have to do more work or less work to move the suitcase? Explain.

$W_{TF} = 95\,N$

$W_{TD} = 15.0\,m$

$W = F \cdot d$

$= 95\,N \cdot 15.0\,m$

$= 1425\,N \cdot m$

$= 1425\,J$

Exercise 2: Katie, a 30.0-kg child, climbs a tree to rescue her cat who is afraid to jump 8.0 m to the ground. How much work does Katie do in order to reach the cat?

$$W = E$$

$$= PE = mgh$$

$$= 30\,kg \cdot 9.8\,\frac{m}{s^2} \cdot 8\,m$$

$$= 2352\,J$$

Exercise 3: Marissa does 3.2 J of work to lower the window shade in her bedroom a distance of 0.8 m. How much force must Marrisa exert on the window shade?

Exercise 4: Atlas and Hercules, two carnival sideshow strong men, each lift 200.-kg barbells 2.00 m off the ground. Atlas lifts his barbells in 1.00 s and Hercules lifts his in 3.00 s. a) Which strong man does more work? b) Calculate which man is more powerful.

Exercise 5: It is said that Galileo dropped objects off the Leaning Tower of Pisa to determine whether heavy or light objects fall faster. If Galileo had dropped a 5.0-kg cannon ball to the ground from a height of 12 m, what would have been the change in PE of the cannon ball?

$$PE = mgh$$

$$= 5\,kg \cdot 9.8\,\frac{m}{s^2} \cdot 12\,m$$

$$= 588\,J$$

Exercise 6: The 2000 Belmont Stakes winner, Commendable, ran the horse race at an average speed of 15.98 m/s. If Commendable and jockey Pat Day had a combined mass of 550.0 kg, what was their KE as they crossed the finish line?

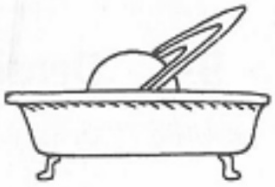
Exercise 7: Brittany is changing the tire of her car on a steep hill 20.0 m high. She trips and drops the 10.0-kg spare tire, which rolls down the hill with an initial speed of 2.00 m/s. What is the speed of the tire at the top of the next hill, which is 5.00 m high? (Ignore the effects of rotation KE and friction.)

Exercise 8: A Mexican jumping bean jumps with the aid of a small worm that lives inside the bean. a) If a bean of mass 2.0 g jumps 1.0 cm from your hand into the air, how much potential energy has it gained in reaching its highest point.
b) What is its speed as the bean lands back in the palm of your hand?

Exercise 9: A 500.-kg pig is standing at the top of a muddy hill on a rainy day. The hill is 100.0 m long with a vertical drop of 30.0 m. The pig slips and begins to slide down the hill. What is the pig's speed at the bottom of the hill? Use the law of conservation of energy.

Exercise 10: While on the moon, the Apollo astronauts enjoyed the effects of a gravity much smaller than that on Earth. If Neil Armstrong jumped up on the moon with an initial speed of 1.51 m/s to a height of 0.700 m, what amount of gravitational acceleration did he experience?

Exercise 1: The planet Saturn has a mass of 5.69×10^{26} kg and a volume of 8.01×10^{23} m^3. a) What is the density of Saturn? b) Would Saturn sink or float if you could place it in a gigantic bathtub filled with water?



Exercise 2: You are handed a 5.00×10^{-3}-kg coin and told that it is gold. You discover that the coin has a volume of 5.90×10^{-7} m^3. You know that the density of gold is 19 300 kg/m^3. Have you really been handed a gold coin, or simply a good imitation?

$$\rho = \frac{m}{V} = \frac{5 \times 10^{-3}\ \text{kg}}{5.9 \times 10^{-7}\ \text{m}^3}$$

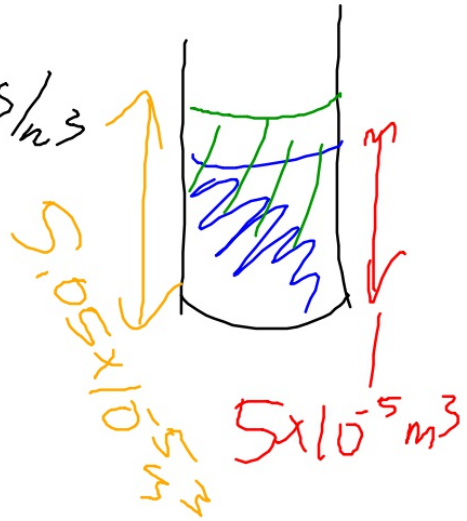
$$= 8475\ \frac{\text{kg}}{\text{m}^3}$$

Exercise 3: Diamond has a density of 3520 kg/m^3. During a physics lab, a diamond drops out of Virginia's necklace and falls into her graduated cylinder filled with 5.00×10^{-5} m^3 of water. This causes the water level to rise to the 5.05×10^{-5}–m^3 mark. What is the mass of Virginia's diamond?

$$D = \frac{m}{V}$$

$$m = V \cdot D$$

$$= 5 \times 10^{-7} m^3 \times 3520 \, kg/m^3$$



$$V_2 - V_1 = 0.05 \times 10^{-5} m^3$$

$$= 5 \times 10^{-7} m^3$$

$$= 5 \times 10^{-7} m^3 \times 3520 \, kg/m^3$$

$$= 0.00176 \, kg$$

$$= 1.76 \times 10^{-3} kg$$

You are given three different liquids—water, oil and glycerin—and asked to predict which will occupy the top, middle, and bottom layers when all three are poured into the same beaker. You take down the following data:

	mass (in kg)	volume (in m^3)
water	0.1000	1.00×10^{-4}
oil	0.0500	5.39×10^{-5}
glycerin	0.0400	3.17×10^{-5}

By finding the densities, determine how these liquids will layer themselves in the beaker from top to bottom.

Exercise 10: The head of a giraffe is 2.0 m above its heart and the density of the blood is 1.05×10^3 kg/m^3. What is the difference in pressure between the giraffe's heart and head? (Fortunately, a giraffe's neck has a special circulatory system to adapt to this neck length, producing an even flow of blood to the head.)

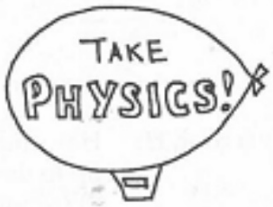
Answer: _____

Exercise 11: How much pressure is needed in ground-based water pipes to pump water up to the restaurant on the top floor of the World Trade Center, 410 m above the ground?

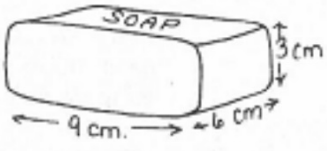
Exercise 12: The difference in pressure between the atmosphere and the human lungs is 1.05×10^5 Pa. What is the longest straw you could use to draw up milk whose density is 1030 kg/m^3?

Exercise 13: Cadir is basting a roast turkey with a meat baster that creates a pressure of 9.980×10^4 Pa when the plastic bulb is squeezed and released. If turkey juice rises 0.0900 m up the tube of the baster, what is the density of the juice?

Exercise 14: A 5450-m^3 blimp circles Fenway Park during the World Series, suspended in Earth's 1.21-kg/m^3 atmosphere. The density of the helium in the blimp is 0.178 kg/m^3. a) What is the buoyant force that suspends the blimp in the air? b) How does this buoyant force compare to the blimp's weight? c) How much weight, in addition to the helium, can the blimp carry and still continue to maintain a constant altitude?



Exercise 15: Ivory soap will float when placed in water so that most of the soap is suspended below the surface, and only a small fraction sticks up above the water line. A bar of soap has dimensions of 9.00 cm × 6.00 cm × 3.00 cm, as shown, and a density of 994 kg/m^3. What is the buoyant force acting on the soap?



$$D = \frac{M}{V}$$

$$m = DV = 994\ \frac{kg}{m^3} \cdot 162\ cm^3$$

$$= 994\ \frac{kg}{m^3} \cdot 162 \times 10^{-6}\ m^3$$

$$= 0.161\ kg$$

Exercise 16: Eliza, the auto mechanic, is raising a 1200.-kg car on her hydraulic lift so that she can work underneath. If the area of the input piston is 12.0 cm^2, while the output piston has an area of 700. cm^2, what force must be exerted on the input piston to lift the car?

Exercise 17: Allegra's favorite ride at the Barrel-O-Fun Amusement Park is the Flying Umbrella, which is lifted by a hydraulic jack. The operator activates the ride by applying a force of 72 N to a 3.0-cm-wide cylindrical piston, which holds the 20 000.-N ride off the ground. What is the diameter of the piston that holds the ride?

Exercise 19: Brandon takes Yvonne on a surprise hot-air balloon ride for her birthday. However, once the pair is airborne, Yvonne announces that she is afraid of heights. The 2200.-m^3 balloon is filled to capacity with 350.0 K air at a height where the surrounding air presure is 1.01×10^5 Pa. When Brandon turns off the heating unit, the air in the balloon begins to cool and the balloon descends. a) Why do both the pressure and volume of the air in the balloon remain constant, even though the balloon's air cools to a temperature of 300.0 K? b) Hot-air balloons are always made so that the bottom remains open throughout the flight. By how much would the balloon's volume change if the balloon could be manually closed as the temperature dropped to 300.0 K? (Assume atmospheric pressure remains constant.)

Answer: **a.** _____

Answer: **b.** _____

Exercise 20: During Annette's first airplane ride, her plane ascends from sea level, where cabin pressure is 1.01×10^5 Pa, to flying altitude, where the cabin pressure drops slightly to 1.00×10^5 Pa despite pressurized conditions. Annette feels a sensation in her middle ear, whose volume is 6.0×10^{-7} m^3. a) What is the new volume of air inside Annette's middle ear? b) What could Annette do to compensate for this change in volume?

A-1: A 1.9–kg piece of wood from a sunken pirate ship has a volume of 2.16×10^{-3} m^3. Will this piece of wood float to the surface of the water or remain submerged with the ship?

A-6: Lucy is going skin diving to see coral off the coast of Mexico in sea water with a density of 1025 kg/m^3. a) How great is the pressure pushing on Lucy at a depth of 20.0 m? b) How will the pressure change if Lucy swims deeper?

A-8: Eileen is floating on her back in the beautiful blue Caribbean during her spring vacation. If Eileen's density is 980 kg/m^3 and she has a volume of 0.060 m^3, what is the buoyant force that supports her in the sea water of density 1025 kg/m^3?

A-9: While swimming in her backyard pool, Nicole attempts to hold a 0.9000-m^3 inner tube completely submerged under the water. a) What buoyant force will be exerted on the inner tube as Nicole attempts to force it under the water? b) When Nicole lets go of the inner tube, it pops up to the surface with a force of 8990. N. What is the weight of the inner tube?

Exercise 3: The barium-yttrium ceramic compound used to demonstrate superconductivity will work only if supercooled to a temperature of 125 K. What is the equivalent temperature a) in °C? b) in °F?

Exercise 2: The highest temperature ever recorded on Earth was 136.4°F at Al' Aziziyah, Libya, on September 13, 1922. The lowest temperature ever recorded was −128.6°F at Vostok, Antarctica, on July 22, 1983. Calculate both of these temperatures in degrees Celsius.

Exercise 4: Most bridges contain interlocking grates that allow the bridge to expand and contract with the change in temperature. The Golden Gate Bridge in San Francisco is about 1350 m long. a) The seasonal temperature variation in San Francisco ranges from about 0°C to 30.°C. How much will the bridge expand between these extremes? ($\alpha_{steel} = 12 \times 10^{-6} °C^{-1}$) b) Approximately how wide is this gap compared to the length of an automobile?

Exercise 5: Selena has a fire in the fireplace to warm her 20.°C apartment. She realizes that she has left the iron poker in the fire. How hot is the fire if the 0.60-m poker lengthens 0.30 cm? ($\alpha_{iron} = 12 \times 10^{-6} {}^{\circ}C^{-1}$)

Exercise 9: Nova, whose mass is 50.0 kg, stays out skiing for too long and her body temperature drops by 2.00°C. What is the amount of heat lost from Nova's body? ($c_{\text{human body}} = 3470$ J/kg°C)

Exercise 10: Phoebe's insulated foam cup is filled with 0.150 kg of the coffee (mostly water) that is too hot to drink, so she adds 0.010 kg of milk at 5.0°C. If the coffee has an initial temperature of 70.0°C and the specific heat of milk is 3800 J/kg°C, how hot is the coffee after the milk is added? (Assume that no heat leaks out through the cup.)

Exercise 12: Finishing his ginger ale, Ramesh stands at a party holding his insulated foam cup that has nothing in it but 0.100 kg of ice at 0°C. How much heat must be gained by the ice in order for all of it to melt?

Exercise 13: In Exercise 12, how much more heat must be gained to raise the temperature of the melted ice to room temperature of 23.0°C?

Exercise 15: While Laurie is boiling water to cook spaghetti, the phone rings, and all 1.5 kg of water boils away during her conversation. If the water was initially at 15°C, how much heat must have been gained for all of it to turn into water vapor?

A-8: Sidney is home from school with a cold, so Mom has made him a bowl of chicken soup (mostly water), which she ladles from a pot into a glass bowl. If 0.600 kg of soup at 90.0°C is placed in a 0.200-kg bowl that is initially at 20.0°C, what will be the temperature of the soup when the bowl and soup have reached equilibrium? (c_{glass} = 840. J/kg°C)

A-9: In A-8 above, when the soup and bowl are at 80.0°C, a chilled dumpling with a mass of 0.100 kg and a temperature of 10.0°C is added. What will be the temperature of the dumpling, soup, and bowl when the three have reached equilibrium? (c_{dumpling} = 110. J/kg°C)

Exercise 1: Terry jumps up and down on a trampoline with a frequency of 1.5 Hz. What is the period of Terry's jumping?

Answer:

Exercise 2: Gary Stewart of Reading, Ohio set a pogo stick record in 1990 by jumping 177 737 times. a) If the pogo stick he used had a force constant of 6000. N/m and was compressed 0.12 m on each jump, what force must Gary have exerted on the pogo stick upon each jump? b) What force would be exerted back up on Gary each time he went up?

At the post office, Cliff, a postal worker, places a 0.60-kg package on a scale, compressing the scale by 0.03 m. a) What is the force constant of the spring in the postal scale? b) What happens to the force constant if Cliff weighs a heavier package?

Exercise 1: A jack-in-the-box lid will pop open when a crank is turned on the outside of the box. If Jack pushes against the inside of the box with a force of 3.00 N when the lid is closed, and the spring is compressed 10.0 cm from equilibrium, what is the force constant of the spring?

Exercise 5: Sam, a butcher, puts 3.0 kg of chopped beef on the 1.0-kg pan of his scale, which has a spring whose force constant is 400. N/m. What is the period of vibration of the pan as it comes to rest? b) If Sam adds more beef to the scale, what will this do to the period of vibration?

Exercise 7: A metronome is a device used by many musicians to get the desired rhythm for a musical piece. If a metronome is clicking back and forth with a frequency of 0.5 Hz, what is the period of the metronome?

Exercise 9: Tegan, a trapeze artist, swings from a 2.5-m-long trapeze, high above the three-ring circus. a) What is Tegan's period of swing? b) Would Tegan's period of swing change if she were more massive? If so, how?

Exercise 10: Danielle is pushing her twin Daniel on a swing that hangs from a tree branch by 2.0-m-long ropes. With what frequency will Danielle have to push Daniel as he swings?

Exercise 11: Marla, a maid, is standing on the Vanderbilt's dining room table dusting the chandelier. While Marla is reaching up, she slips and grabs hold of the chandelier to catch her balance. When she lets go, the chandelier begins to swing with a period of 1.6 s. How long is the cable connecting the chandelier to the ceiling?

Exercise 12: You have been commissioned by NASA to travel to Jupiter's innermost Galilean satellite, Io, to learn more about this volcanic moon. As you board the spacecraft, you are handed a rock tied to a 10.0-cm string, and a stopwatch, and are asked to derive an experiment that would allow you to determine the acceleration due to gravity on Io. You must use both pieces of equipment and nothing more. a) Describe how you would calculate Io's gravitational acceleration. b) If the pendulum swings with a period of 1.48 s, what is the gravitational acceleration on Io?