Basic Physics 29:008 Exam II Spring 2005

Name: _____Solutions_____ Date: _____

1. Which of these is impossible, by the second law of thermodynamics?

A) A ship is powered by heat from the ocean, waste heat being dumped to the night sky.
B) Heat energy from a thermally isolated system is converted into work only.
C) A heat pump delivers more heat to a house than the energy required to operate it.
D) A heat engine converts heat to work with 99% efficiency.

A) This is possible because the night sky can be colder than the ocean.
->B) This is precisely what the second law says you can't do.
C) Heat pumps always do this for you.
D) This is certainly possible since it is less than 100%.

2. The skinny tires of a 10-speed racing bicycle require more air pressure than the fat tires on an equally massive mountain bike because

A) the racing bike moves faster.
B) the area of contact of the racing bike's tires is greater than that of the bike with fat tires.
C) the racing bike touches the ground over a smaller area than the bike with fat tires.
D) the racing bike exerts more force on the ground.

This is a question about the definition of pressure. The bikes have about the same weight, but since the racing bike touches the ground over a smaller area F/A = P is larger than for the mountain bike. The answer is C.

3. The second law of thermodynamics says that the total amount of entropy, or randomness, in the universe cannot decrease. However, we see all around us objects that become more ordered - - for example, water that freezes. The decrease in entropy, or randomness, in such cases does not violate the second law because

A) there is always a greater increase in entropy somewhere else.
B) energy must be added.
C) energy must be removed.
D) water does not have entropy.

When water freezes, the entropy goes down, but the heat has left the ice and gone somewhere else. Since the heat will flow to someplace colder, the entropy somewhere else will go up because S=Q/T. Therefore the answer is A.

4. An ice cube of mass 100 g and at 0^oC is dropped into a Styrofoam cup containing 200 g of water at 25^oC. The heat of fusion of ice is 80 cal/g and the specific heat capacity of water is 1.0 cal/g C°. Assuming the cup doesn't exchange any heat, the final temperature of the system will be which of the following?

A) -10^oC.
B) 0^oC.
C) $+2.5^oC$.
D) $+5.0^oC$.
E) $+10^oC$.

Using L_f=80cal/g and Q=m L_f we find that : 100g*80cal/g=8000 cal are needed to melt the ice but only 200g*1cal/g/deg*25 deg = 5000 cal to cool the water down to 0^oC (using $Q=mc\Delta T$). So some of the ice will melt, and the water will cool down to 0^oC. However, you will still have

an ice-water mixture after the water is cooled down. This will be at 0^oC. **Answer: B** To be more precise you can see that there will still be 3000/80=37.5 grams of ice left and a total of 200+62.5=262.5 grams of liquid water- but you were not asked that….

5. A gun is made of a super-low weight but strong material. The bullet for the gun is more massive than the gun itself. For such a gun

A) recoil problems would be lessened.
B) the gun, if unsupported, would have a recoil velocity higher than the bullet velocity.
C) the bullet will have less recoil momentum than the gun.
D) the gun will have less recoil momentum than the bullet.

This is a classic recoil problem. The bullet and gun have equal and oppositely directed momenta. Since the gun has less mass it will have a greater velocity so that mass times velocity will be the same. The answer is B.

6. The bigger gears on the rear wheel of a multi-speed bike allow the rider to

A) exert more force on the wheel.
B) exert more torque on the wheel.
C) increase the moment of inertia of the wheel.
D) decrease the moment of inertia of the wheel.

For the same tension in the chain, the force is the same, but if you increase the rear gear diameter you increase the lever arm *l*. Using $\tau = F_{\perp} l$ this means there will be more torque. Answer B

7. Compare the internal energy of one gram of steam to that of one gram of water if both are at 100° C.

A) The internal energy of the water and steam are the same.
B) The internal energy of the water will be higher.
C) The internal energy of the steam will be higher.

The steam has extra internal energy that it got when the water was vaporized. It took an extra 540 cal/gram to make the steam from water at 100° C. The internal energy of the steam is higher. Answer C.

8. A 3000-kg truck traveling with a velocity of 5m/s due north collides head-on with a 1500-kg car traveling with a velocity of 20 m/s due south. The two vehicles stick together after the collision. What are the size and direction of the total momentaum of the two vehicles after they collide

A) 15000 kg m/s North
B) 15000 kg m/s South
C) zero
D) 30000 kg m/s South

Take north as the positive direction. The total initial momentum is the sum of the momenta of the truck and the car. Momentum is mass times velocity.
For the truck: p=mv=3000 kg * 5m/s=15000 kg m/s
For the car: p=1500 kg * (-20 m/s) = -30000 kg m/s the sum is -15000 kg m/s (ie. South)
By conservation of momentum this is the total momentum after the collision. Answer B

9. A hydraulic jack is used to lift a load of weight 1000 N. The load-bearing cylinder has a radius of 4 cm, and the other piston has a radius of 1 cm. What force must be exerted on the smaller piston to support the load?

A) 62.5 N
B) 125 N
C) 250 N
D) 1000 N
E) 4000 N

The pressure is the same at both ends in the hydraulic lift (Pascal's principle). If the radius of the smaller piston is ¼ of the radius of the load bearing cylinder then the area is 1/16 (it goes as the square) this means that the force F=P*A is smaller by a factor of 16. 1000N/16=62.5N Ans:A

10. A well insulated room has a refrigerator in it that is running and has the door open.

A) The room will gradually get colder.
B) The room will gradually get warmer.
C) There can be no net change in the room temperature.

This is very much like one of the homework problems. The refrigerator uses electricity which gets converted into heat – and also it pumps heat. Since the door is open the heat goes round and round but there is extra heat added from the electrical input. The total heat in the room increases so it will get gradually warmer. Answer B

11. The rotational inertia of an object depends on which of these?

A) Its color.
B) How fast it is spinning.
C) The amount of torque applied to it.
D) How its mass is distributed about the spin axis.
E) None of the above.

The rotational inertia depends not only on the total mass, but on how it is distributed about the spin axis. ($I=mr^2$) Answer D

12. Archimedes Principle states that

A) the pressure in a fluid is directly related to the depth below the surface of the fluid.
B) an object immersed in a fluid is buoyed up by a force equal to the weight of the displaced fluid.
C) the pressure of a fluid is inversely proportional to the temperature of the fluid.
D) the velocity of a fluid is directly proportional to the pressure exerted on the fluid.

This is a definition. Answer B

13. A body of rotational inertia 1.0 kg m^2 is acted upon by a torque of 2.0 Nm. The angular acceleration of the body will be:

A) 0.5 rad/s^2.
B) 0.5 rev/s^2.
C) 1.0 rad/s^2.
D) 2.0 rad/s^2.
E) 2.0 rev/s^2.

$\tau_{net} = I\alpha$ 2.0 Nm=(1.0 kg m2)*α. α=2 radians/sec^2. The radian is the natural unit of angle. D

14. Four samples of steel, lead, alcohol and glass all have the same mass and are all initially at 20°C. After 100 calories of heat is added to each sample, the final temperat ures are 38.2°C for the steel, 85.6°C for the lead, 23.4°C for the alcohol, and 30°C for the glass. Which of these four materials has the largest specific heat capacity?

A) The steel.
B) The lead.
C) The alcohol.
D) The glass.
E) All have same heat capacity, since all absorbed 100 cal of heat.

Because Q=100 cal is the same, and the mass is the same, for each we can use Q=mcΔT to determine the relative heat capacities "c" from their ΔT. The material with the largest heat capacity will have the smallest temperature rise ΔT. This means that the alcohol has the largest heat capacity. Answer C

15. Suppose you are out on a frozen lake, where there is no friction. Which of the following would start you moving towards the shore?

A) Shouting at someone on the shore.
B) Removing a shoe and throwing it towards the shore.
C) Removing a shoe and throwing it away from the shore.
D) None of these would work.

Shouting produces negligible recoil. When you throw a shoe you will recoil in the opposite direction from the shoe so it makes sense to throw the shoe away from the shore. Answer C.

16. The primary function of any heat engine is to

A) convert work into heat.
B) create energy.
C) convert heat into work
D) destroy energy and replace it with work

This is a definition. Answer C.

17. A wheel starting from rest has a constant angular acceleration of 10 rad/s^2 how much will the wheel have rotated after 5 seconds?

A) 25 rad.
B) 50 rad.
C) 50 rev.
D) 125 rad.

Here we need to use the equation: $\theta = \omega_0 t + \frac{1}{2}\alpha t^2$ The wheel starts from rest so we only need $\theta = \frac{1}{2}\alpha t^2$ If α=10 rad/s^2 and t=5 seconds θ= ½ (10)*5^2=125 rad.

18. How does the velocity of air moving over the top of the wing of an airplane in flight compare to the velocity of air moving under the wing?

A) The velocities are the same.
B) The velocity over the wing is greater.
C) The velocity under the wing is greater.

Bernoulli's principle: the pressure is lower and velocity is greater over the wing. Answer B

19. A certain amount of heat is transferred to a system, and the system performs some work on its surroundings. The amount of work done is less than the heat added. Thus

A) the internal energy of the system increased.
B) the internal energy of the system decreased.
C) the total energy was not conserved.
D) the entropy of the system must have decreased.
E) there must have been a phase change.

This is an application of the first law of thermodynamics $\Delta U = Q - W$ we are told that W is less than Q therefore there is an increase in internal energy $\Delta U > 0$. Answer A

20. In a head-on automobile collision, a person's momentum could be reduced from 2000 kg m/s to zero in just 0.1 s. If this occurs, the average force exerted to stop the person is

A) 200 N.
B) 2 000 N.
C) 20 000 N.
D) Can't answer without knowing the person's mass.

Here we use the equation $\vec{F} \cdot \Delta t = \Delta \vec{p}$. The momentum change is 2000 kg m/s and the Δt is 0.1 seconds. Therefore F is 2000/0.1=20000 N. Answer C.