PHY101: Solutions to Review Packet for Final

1) D—Units on the left hand side must equal the units on the right hand side; pressure/velocity can be reduced to $(\text{m/s})^2$ so the answer is D.

2) B—See Periodic table.

3) C—$v = a\Delta t$.

4) D

5) C—$W = F\Delta x \cos(\theta)$. Since $\theta = 90$, $W = 0$.

6) E

7) A

8) B—The coffee cup is at a higher temperature, however, there are many more molecules in an iceberg than a coffee cup and since the internal energy is proportional to the total number of molecules, the iceberg has more internal energy than the coffee cup.

9) B

10) C—First law of thermodynamics.

11) D—Since the average kinetic energy (internal energy) is proportional to temperature, if the temperature is fixed, so is the internal energy and (the molecular speed)

12) A

13) A—Water has a larger specific heat capacity.

14) B—Opposite charges attract so the particles want to move closer together and therefore the electrical force between them increases via Coulomb's Law.

15) B—Resistors in parallel have a total lower resistance so that for a fixed voltage, the current is larger via Ohm's Law.

16) C

17) Since $\Delta v = a \cdot \Delta t$ since in our case $\Delta v = -100$ km/hr then:

$$a = \frac{\Delta v}{\Delta t} = -10 \text{ km/(hr s)} \tag{1}$$

18) Newton's second law:

$$\vec{F} = m\vec{a} \tag{2}$$

says that a body is going with constant velocity only if the total force acting on it is zero

a. Since after the terminal velocity has been reached the velocity won't change anymore it means that once that velocity is reached the total force has to be zero. The only force acting on Suzie is gravity and is equal to $\vec{F}_g = m\vec{g} = 500\ N$, then the air resistance for the previous considerations has to be equal and opposite:

$$\vec{F}_{air} = -\vec{F}_g = -500\ N \tag{3}$$

b. The same as before, -500 N, but Suzi is moving with a lower terminal velocity (larger parachute).

c. The answer is the same for both, but (b) occurs at a lower terminal velocity.

19) a. Using the relation of 17) and 18) we can get:

$$\Delta v = \frac{F}{m}\Delta t \quad \Longrightarrow \quad \Delta t = \frac{\Delta v \cdot m}{F} \tag{4}$$

but since the final velocity is zero $\Delta v = v - 0 = v$ from which follows the solution.

b. Putting the numbers in:

$$\Delta t = \frac{20 \cdot 3}{15}s = \frac{60}{15}s = 4s \tag{5}$$

20) a. After the penny leave the table, since has only horizontal velocity, will move at constant velocity v along the horizontal and will uniformly accelerate along the vertical with initial velocity zero. The distance covered along the horizontal will then simply be the constant velocity times the time the penny take to touch the ground (that's the meaning of constant velocity motion). We then need to calculate the time takes to touch the ground, since the initial velocity along the vertical is zero this is just $t_f = \sqrt{\frac{2y}{g}}$ then we get the answer:

$$d = v \cdot t_f = v\sqrt{\frac{2y}{g}} \tag{6}$$

b. Putting the numbers in we get:

$$d = 3.5\sqrt{\frac{0.8}{10}}m = 3.5 \cdot 0.283m = 0.99m \approx 1m \tag{7}$$

21) The heat exchange by any material is $Q = mc\Delta T$ where c is the specific heat of the material and ΔT is the change in temperature. Using the superscript I and W to refer respectively to quantity referring to the nails and to the water, and recalling that in our case the masses of the two system are the same ($0 = Q_I + Q_W$):

$$mc^I \cdot (T_i^I - T_f) = mc^W \cdot (T_f - T_i^W) \quad \Longrightarrow \quad T_f = \frac{T_i^W c^W + T_i^I c^I}{c^W + c^I} \tag{8}$$

since $T_i^W = 20°$, $T_i^I = 40°$, $c^W = 1\ cal/g\ °C$ and $c^I = 0.12\ cal/g\ °C$ we get:

$$T_f = \frac{20 + 4.8}{1.12}\ °C = 22.14°C \tag{9}$$

The solution in the book is wrong!

22) a. The voltage on the secondary is $V_s = \frac{n_s}{n_p} V_p$ where n_p and n_s are the number of turns respectively in the primary and the secondary and V_p is the voltage on the primary. Putting the numbers in we get:

$$V_s = \frac{250}{50} 12\ V = 60\ V \tag{10}$$

b. By Ohm's law $I = \frac{V}{R}$ we get:

$$I_s = \frac{V_s}{R} = \frac{60}{10} A = 6\ A \tag{11}$$

c. The power dissipated in the secondary should be equal to the one supplied to the primary. Since the former is $W = I_s^2 R = 36 \cdot 10\ W$ we get the answer.

23) If we neglect air resistance all the forces (only gravity) are conservatives. We can then use conservation of energy to calculate the final speed. Since all of three have as initial energy only the kinetic energy plus the potential one (mgh):

$$E^i = \frac{1}{2} m v_i^2 + mgh \tag{12}$$

where h is the height of the cliff. At the ground the potential energy is completely converted in kinetic one then the final speed will be:

$$E^f = \frac{1}{2} m v_f^2 = \frac{1}{2} m v_i^2 + mgh \qquad \Longrightarrow \qquad v_f = \sqrt{v_i^2 + 2gh} \tag{13}$$

For the horizontal case, $v_{yf}^2 - v_{yi}^2 = v_{yf}^2 = 2gh$ and $v_{xf} = v_{xi} = v_i$, so using the Pythagorean's theorem, $v_f = \sqrt{v_{yf}^2 + v_{xf}^2} = \sqrt{v_i^2 + 2gh}$.

a. they are all equal

b. using the formula above we find $v_f = \sqrt{100 + 300}\ m/s = 20\ m/s$

24) Since energy is conserved the initial one which is only the potential energy of Jones at 3.7 m above the ground has to be equal to the final one which is the sum of the potential energy of Jones and the one of Georgia at the final height:

$$E^i = E^f \quad \Longrightarrow \quad m_J g h_i = (m_J + m_G) g h_f \quad \Longrightarrow \quad h_f = \frac{h_i m_J}{m_J + m_G} = \frac{288.6}{133} m = 2.17m \tag{14}$$

25) Recalling that the work is:

$$W = P \cdot \Delta V \tag{15}$$

if there is no change in volume there is no work done from or on the system. Also, a unit of pressure is atm (atmosphere). However, the metric unit of pressure is Pa (Pascal). This is covered in Chapter 7, which we did not cover so this info would be given in the problem. It turns out that 1 atm correspond to $10^5\ N/m^2$.

a. Along the top line $\Delta V = 0.6\ m^3$ and $P = 4\ atm$ so $W_1 = 2.4 \cdot 10^5 J$. Both the vertical lines do not contribute since along those there is no change in volume. Finally along the bottom line we have $\Delta V = -0.6\ m^3$, $P = 1\ atm$ and so $W_2 = -0.6 \cdot 10^5 J$. The total work is just the sum of all the contributions, that is:

$$W_{tot} = W_1 + W_2 = 1.8 \cdot 10^5 J \tag{16}$$

b. Since it is a cycle and then the net change of the internal energy of the engine vanishes, from the first principle of thermodynamics the work done has to be equal to the net heat exchanged:

$$Q_{tot} = W_{tot} = 1.8 \cdot 10^5 J \tag{17}$$

26) The specific heat for the steel is $c^S = 500\ J/kg\ °C$. We can break this problem up into two parts. Perhaps this will make it easier. After the ball falls into the water, the kinetic energy of the ball will be converted into heat, i.e. the ball will get hotter (which will lead to a slightly higher temperatre of the system ultimately due to this "extra" mechanical energy). By the first law of thermodynamics, that heat is:

$$m^S c^S \Delta T = m^S gh \quad \Longrightarrow \quad \Delta T = \frac{gh}{c^S} = \frac{100}{500}\ °C = 0.2°C \tag{18}$$

We now need to do the same as we did in 21) but now the two masses (the steel ball and the water) are different. Follows then that:

$$m^S c^S (T_i^S - T_f) = m^W c^W (T_f - T_i^W) \tag{19}$$

which implies

$$T_f = \frac{m^W c^W T_i^W + m^S c^S T_i^S}{m^S c^S + m^W c^W} = \frac{190253.7 + 56210}{3650 + 18837} = 10.96°C \tag{20}$$

Note that we have used $T_i^S = 15.4$ degrees C (the extra heat) and $T_i^W = 10.1$ degrees C.

27) The electromagnetic force takes the form:

$$\vec{F}_{e-m} = q(\vec{E} + v \times \vec{B}) \tag{21}$$

where $\times$ is the vector product between the two vectors. In other words, the magnitude of the magnetic force is $qvB\sin(\theta)$, where θ is the angle between the velocity vector and the direction of the magnetic field (a vector) and the direction is given by the right hand rule. The essential feature is that the force due by the magnetic field is perpendicular to both the velocity and the field itself.

a. Since the charge of the electron is equal to $q_e = 1.6 \cdot 10^{-19} C$ there is a force pulling the electron toward the west (because the electron has a negative charge) equal to:

$$F_e = qE = 3.2 \cdot 10^{-15}\ C\ V/\ m \tag{22}$$

whereas the magnetic force will be perpendicular to both the electric force and the velocity (its direction is into the page) and will be equal to:

$$F_m = qvB = 8 \cdot 10^{-15}\ C\ V/\ m \tag{23}$$

b. Since the electric force will be always perpendicular to the magnetic one, there is no way the can cancel each other completely.

28) To solve this problem we have to recall Faraday's law:

$$V_{ind} = -\frac{\Delta\phi_B}{\Delta t} \tag{24}$$

where $\Delta\phi_B$ is the change of flux during a time Δt. Also the charge flowing through a resistance in a given time is equal to the current through the resistance times the given time.

a. When we rotate the circuit 180 degrees the flux goes from $\phi_B = 0.45^2 \cdot 50 \cdot 1.4\ T \cdot m^2 = 14.17\ T \cdot m^2$ to $\phi_B = -14.17\ T \cdot m^2$ so:

$$\Delta\phi_B = 28.34\ T \cdot m^2. \tag{25}$$

Since $V_{ind} = I_{ind}R_{tot} = \frac{\Delta q_{ind}}{\Delta t}R_{tot}$ and the total resistance of the parallel circuit is:

$$\frac{1}{R_{tot}} = \left(\frac{1}{5} + \frac{1}{10}\right)\Omega = \frac{3}{10}\Omega \quad \Longrightarrow \quad R_{tot} = 3.33\ \Omega \tag{26}$$

we can get the total charge flowing through the whole circuit via $\frac{\Delta q_{ind}}{\Delta t}R_{tot} = \frac{\Delta\phi_B}{\Delta t}$, or

$$q_{ind} = \frac{\Delta\phi_B}{R_{tot}} = 8.51\ C \tag{27}$$

b. Since the current flowing through the 5Ω resistance is equal:

$$I_{5\Omega} = I_{tot}\frac{10}{15} = I_{tot} \cdot 0.67 \tag{28}$$

where I_{tot} is the current flowing in the whole circuit, then the charge flowing through that resistance will be 0.67 times the one calculated above, that is:

$$Q_{5\Omega} = q_{ind} \cdot 0.67 = 5.67\ C \tag{29}$$