Physics 200 Name: ______________________________

Final Exam Practice Problems -- **UPDATED**

Energy, Work, and Circuits

***For this problem, disregard rotational energy; you can pretend the car has massless wheels.*

A 1,600kg Nissan Leaf (electric car) was traveling at a speed of 20m/s on level ground. When the driver applied the brakes, “regenerative braking” turned the car’s mechanical energy into electric energy, charging the 400V battery while bringing the car to the stop. Answer the following questions about this car. To simplify calculations, assume that the car is 100% efficient; no energy is lost to heat or “other energy.”

1. Assuming that all of the car’s lost mechanical energy is turned into energy stored in the battery, how much energy was added to the battery? *Remember to ignore rotational KE. Pretend the wheels are massless.*
2. If the car took 5s to come to a stop, what average amount of power was used to charge the battery?
3. How much current (on average) flowed into the battery?
4. How much charge flowed through the battery?
5. If the car took 5s to come to a complete stop, what was the average braking force?
6. During that stop, how much work was done on the car?
7. Over what distance did the car come to a stop?

The same car drives up a hill…

8. How much energy would be required for the car to drive up a 30m tall hill – assuming that the car started from rest and came to rest again at the top of the hill?
9. How much charge would need to flow through the battery in order to get to the top of that hill?
10. If a constant current of 2A flowed from the car’s battery as it ascended the hill…
    a. How much power would the car use?
    b. How much work would its motor do?
    c. How long would it take for the car to get to the top of the hill?

Battery Capacity –If this Nissan leave has the smaller optional battery, which stores 40kWh of energy…

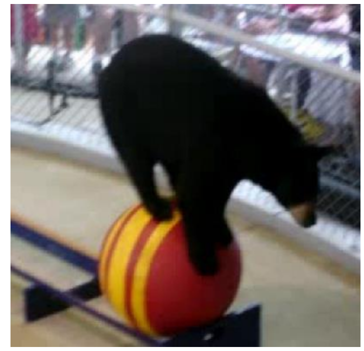
11. Skip
12. How many joules is 40kWh?
13. How much average current would be required in order to fully discharge the battery during a 2 hour drive?
14. How many Coulombs of charge would need to flow through the battery in that time?

Momentum and Impulse

15. A 10kg cart traveling rightward with a speed of 3m/s collides with a second cart, which is traveling leftward at a speed of 2m/s. After the collision, the 10kg cart is traveling leftward with a speed of 1m/s and the second cart travels rightward at 4m/s.
    a. What is the mass of the 2^{nd} cart?
    b. Is this collision elastic or inelastic? How do you know?
    c. How does the total KE before the collision compare to the total KE after the collision?

16. Suppose the same two carts collided as described above, but the 2^{nd} cart’s velocity after the collision was also 1m/s leftward (just like the 10kg cart).
    a. In this case, what’s the mass of the 2^{nd} cart.
    b. Is this collision elastic or inelastic? How do you know?
    c. How does the total KE before the collision compare to the total KE after the collision?

Rotational Motion



A trained bear is initially standing motionless on a ball. The ball's radius is 0.4m. Suddenly the bear shifts its weight and begins to walk, causing the ball to roll. The bear exerts a constant 1.2N force tangent to the ball's surface. The bear continues to exert this force for 3 seconds -- until the ball is rolling across the ground at a speed of 2m/s. The bear maintains this 2m/s speed for another 3 seconds and then jumps off, allowing the ball to roll to a stop over an additional distance of 25m.

17. Find the net Torque exerted on the ball during…
    a. The first 3 seconds of acceleration
    b. The 3 seconds of moving at constant speed
    c. The deceleration period (*tricky)

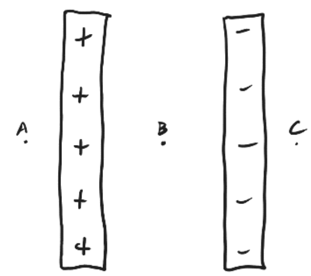
18. What is the ball's angular acceleration during the first 3 seconds?
19. What is the ball's angular displacement during the first 3 seconds?
20. How far does the ball roll during the first 3 seconds?
21. What is the total distance traveled by the ball?
22. What is the ball's moment of inertia?
23. What is the ball's maximum angular velocity?
24. What is the ball's angular momentum when it is rolling at top speed?
25. After the bear jumps off, how long does it take the ball to roll to a stop?
26. If the moment of inertia for the ball can be calculated with $I = 2/5mr^2$, what was the maximum total kinetic energy of the ball?

27. A frictionless block, a solid disk, a hollow hoop, and a sphere are released from the top of a 1m tall ramp.
    a. Which object will have the fastest speed when it reaches the bottom?
    b. What speed will that object have?
    c. Which object will be the slowest?
    d. Explain why the fastest object is faster than the rest.

Electric Charge and Electric Field (electrostatics)

28. a. Use electric field lines to draw the electric field around the point charges on the right.
b. For each lettered location, describe the direction of the force experienced by a proton and an electron at that location.

29. a. Use electric field lines to draw the electric field around the charged plates on the right.
b. For each lettered location, describe the direction of the force experienced by a proton and an electron at that location.



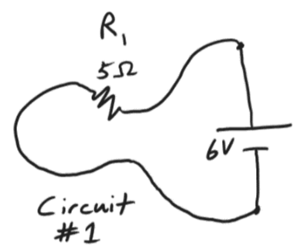
30. If a proton ($+1.6\times10^{-19}$C) located somewhere in one of your diagrams experience an electric force of 1N, what is the magnitude of the electric field at that location?

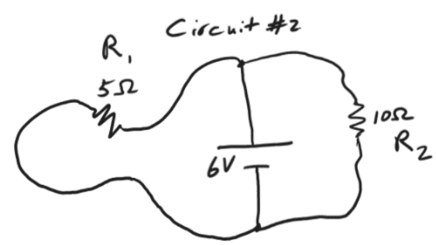
31. What magnitude force would be experienced by an electron at that same location?

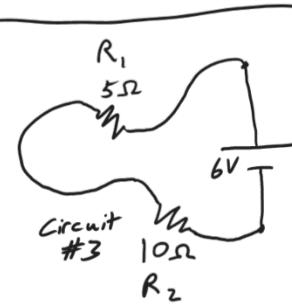
32. What is the root cause of the forces that charges experience when they are in an electric field.

33. Using only field lines, draw..
a. a weak, uniform electric field
b. a stronger, uniform electric field
c. a non-uniform electric field; label a stronger and a weaker part of the field

34. Which force -- electric force or gravitational force -- is dominant on large scales, and which force is dominant on small scales? Explain why.







Current and Circuits Someone builds circuit #1 using a 5Ω resistor and a 6V battery. Then they create circuits #2 and #3 by adding a 10Ω resistor, but they do it in two different ways.

35. Find every V, I, R, and P in each of the circuits.

36. In which circuit was the 10Ω resistor added in parallel? What qualifies it as that type of circuit?

37. In which circuit was the 10Ω resistor added in series? What qualifies it as that type of circuit?

38. Compare and contrast what happens to the source voltage, current, and power when a new resistor is added to the circuit in series vs parallel. Explain the reason for any differences.

Provided Formulas:

$PE = mgh \quad KE_{Trans} = \frac{1}{2}mv^2$

$PE_0 + KE_0 + W_{NC} = PE + KE$

$P = \frac{W}{\Delta t} \quad W = Fd$

New additions are in grey

$p = mv \quad Ft = \Delta p \quad Ft = m\Delta v$

$m_1 v_1 + m_2 v_2 = m_1' v_1' + m_2' v_2'$

$e = \frac{\text{sep. } v}{\text{Closing } v}$

$\tau = Fr \quad \tau = I\alpha \quad \alpha = \frac{\Delta \omega}{\Delta t} \quad \omega = \omega_0 + \alpha t$

$\omega = \frac{\Delta \theta}{\Delta t}$

$s = \theta r \quad a = \alpha r \quad v = \omega r \quad \Delta\theta = \omega_0 t + \frac{1}{2}\alpha t^2$

$a = \frac{\Delta v}{\Delta t}$

$KE_{Rot} = \frac{1}{2} I \omega^2 \quad L = I\omega \quad \omega^2 = \omega_0^2 + 2\alpha\Delta\theta$

$\bar{v} = \frac{\Delta x}{\Delta t}$

$PE_0 + KE_{Rot\,0} + KE_{Trans\,0} = PE + KE_{Rot} + KE_{Trans}$

$\bar{v} = \frac{v_0 + v}{2}$

$F_e = k\frac{q_1 q_2}{r^2} \quad E = \frac{F_e}{Q}$

$E = QV$

$I = \frac{\Delta Q}{\Delta t} \quad I = \frac{V}{R} \quad P = IV = I^2 R = \frac{V^2}{R}$

$R = \frac{\rho L}{A} \quad A = \pi r^2$

$R_{series} = R_1 + R_2 + R_3 \ldots \quad \frac{1}{R_{parallel}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \ldots$