Name______Answer Key__________ Date ____________________________

SI Physics SI Level Problems

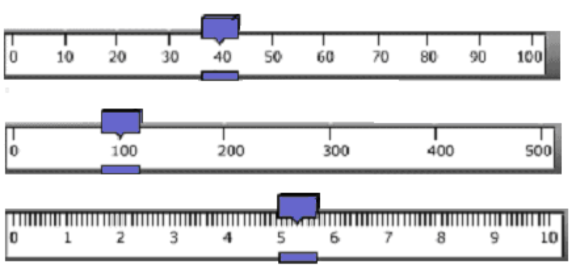
Period ______________ Mrs. Nadworny

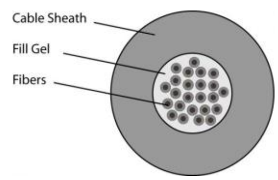
Honors Level Problems

Directions: Each question below represents the "Honors Level" problem from each chapter. Complete the problems on a separate sheet of paper, showing all work with the GUESS method and proper significant figures.

Measurements and Mathematics:

1. The first diagram shows an enlarged view of a triple beam balance, which measures in grams. Record the appropriate mass reading in kilograms, including proper uncertainty. The second diagram shows the cross section of a fiber optic cable. Measure and record the diameter of the cable, including proper uncertainty. The third diagram below shows a stopwatch used to record an event. Record the time in proper units, including proper uncertainty.





0.14530 kg ± 0.00002 kg 0.0210 m ± 0.0002 m 225.3 s ± 0.2 s

Kinematics:

2. A rocket is launched with an initial velocity of 20.5 meters per second upward from a platform 12.5 meters high. Determine the flight time of the rocket.

$$d = v_i t + \tfrac{1}{2}at^2$$

$$-12.5m = (20.5\,\tfrac{m}{s})t + \tfrac{1}{2}(-9.81\,\tfrac{m}{s^2})(t^2)$$

Quadratic Equation!

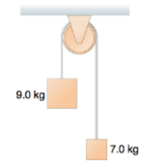
$$4.9t^2 - 20.5t - 12.5 = 0$$

$$t = \frac{-(-20.5) \pm \sqrt{(-20.5)^2 - 4(4.9)(-12.5)}}{2(4.9)}$$

$$t = 4.72s \text{ and } -0.540s$$

Forces:

3. Two masses are hung as shown over a frictionless, massless pulley. Determine their acceleration. Calculate the tension in the rope.



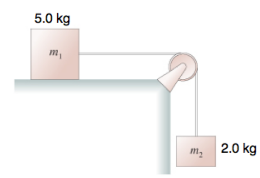
$$a = \frac{F_{net}}{m_{net}} = \frac{F_{g1} - F_{g2}}{m_1 + m_2}$$
$$a = \frac{m_1 g - m_2 g}{(m_1 + m_2)} = \frac{(m_1 - m_2)g}{(m_1 + m_2)}$$
$$a = \frac{(9.0kg - 7.0kg)(9.81\tfrac{m}{s^2})}{(9.0kg + 7.0kg)}$$
$$a = 1.2\tfrac{m}{s^2}$$

$$F_{net} = ma$$
$$F_T - F_g = ma$$
$$F_T = ma + F_g$$
$$F_T = (7.0kg)(1.2\tfrac{m}{s^2}) + (7.0kg)(9.81\tfrac{m}{s^2})$$
$$F_T = 77N$$

OR

$$F_{net} = ma$$
$$F_T - F_g = ma$$
$$F_T = ma + F_g$$
$$F_T = (9.0kg)(-1.2\tfrac{m}{s^2}) + (9.0kg)(9.81\tfrac{m}{s^2})$$
$$F_T = 77N$$

4. A 5.0 kilogram block rests on a horizontal table of negligible friction. A string is tied to the block and passed over a pulley and a 2.0 kilogram block is hung on the other end of the string as shown. Calculate the acceleration of the system. Calculate the tension in the rope.



$$a = \frac{F_{net}}{m_{net}} = \frac{F_{g\ hanging}}{m_1 + m_2}$$
$$a = \frac{m_2 g}{(m_1 + m_2)}$$
$$a = \frac{(2.0kg)(9.81\tfrac{m}{s^2})}{(2.0kg + 5.0kg)}$$
$$a = 2.8\tfrac{m}{s^2}$$

$$F_{net} = ma$$
$$F_T - F_g = ma$$
$$F_T = ma + F_g$$
$$F_T = (2.0kg)(-2.8\tfrac{m}{s^2}) + (2.0kg)(9.81\tfrac{m}{s^2})$$
$$F_T = 14N$$

OR

$$F_{net} = ma$$
$$F_T = ma$$
$$F_T = (5.00kg)(2.8\tfrac{m}{s^2})$$
$$F_T = 14N$$

Universal Gravitation:

5. Planet Blue, which has a mass of 4.13×10^{22} kg, has a radius of 3.26×10^{6} meters. Calculate the acceleration due to gravity on the planet.

$$g = \frac{Gm_1}{r^2} = \frac{(6.67\times10^{-11}\,\tfrac{N\cdot m^2}{kg^2})(4.13\times10^{22}\,kg)}{(3.26\times10^{6}\,m)^2} = 0.259\tfrac{m}{s^2}\ \text{down}$$

Circular Motion:

6. A worker tightening a bolt exerts a force of 6.5 newtons on the end of a 0.25 meter long wrench. Calculate the magnitude of the torque.

$$\tau = F \cdot r = (6.5N)(0.25m) = 1.6Nm$$

7. Two children sit on a see-saw that is 9.0 meters long and pivoted on an axis at its center. The first child has a mass of 20. kilograms and sits at the left end of the see-saw. The second child has a mass of 40. kilograms and sits somewhere on the see-saw to the right of the axis. At what distance from the axis should the second child sit to keep the see-saw horizontal?

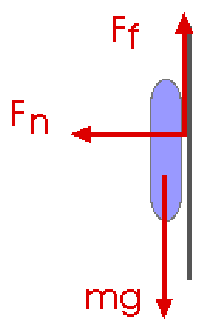
$$\tau_1 = \tau_2$$
$$F_1 \cdot r_1 = F_2 \cdot r_2$$
$$m_1 \not{g} \cdot r_1 = m_2 \not{g} \cdot r_2$$
$$r_1 = \frac{m_2 r_2}{m_1} = \frac{(20.kg)(4.5m)}{40.kg} = 2.3m$$

8. A 2500. kg car attempts to turn a corner going at a speed of 18 m/s. The radius of the turn is 20. meters. How much friction is needed to negotiate this turn successfully?

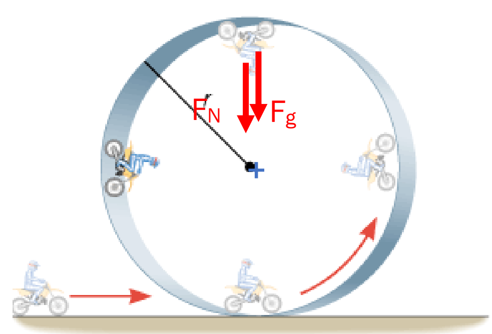
$$F_f = F_c$$
$$F_f = \frac{mv^2}{r}$$
$$F_f = \frac{(2500.\text{ kg})(18\text{ m/s})^2}{20.\text{ m}}$$
$$F_f = 4.1 \times 10^4\text{ N}$$

9. At amusement parks, there is a popular ride where the floor of a rotating cylindrical room falls away, leaving the backs of the riders "plastered" against the wall. The ride has a diameter of 9.0 meters and rotates with a maximum speed of 8.5 meters per second. Calculate the coefficient of friction between the rider's back and the wall.

$$F_{FY} = F_g \quad \text{AND} \quad F_{cx} = F_N$$
$$F_{FY} = mg \quad \text{AND} \quad F_N = \frac{mv^2}{r}$$
$$\mu F_N = mg$$
$$\mu\left(\frac{mv^2}{r}\right) = mg$$
$$\mu = \frac{mgr}{mv^2}$$
$$\mu = \frac{rg}{v^2} = \frac{(4.5m)(9.81\,\frac{m}{s^2})}{(8.5\,\frac{m}{s})^2} = 0.61$$



10. A 95 kilogram stunt motorcyclist on a 255 kilogram bike rounds a 14.0 meter diameter loop-the-loop. What force does the track exert on the bike at the top of the loop where the speed of the bike is 28 meters per second?



$$F_{net} = F_c = \frac{mv^2}{r}$$
$$F_N + F_g = \frac{mv^2}{r}$$
$$F_N = \frac{mv^2}{r} - mg$$
$$F_N = \frac{(95\text{ kg} + 255\text{ kg})(28\text{ m/s})^2}{7.0\text{ m}} - (350.\text{ kg})(9.81\text{ m/s}^2)$$
$$F_T = 35767\text{ N} = 3.6 \times 10^4\text{ N down}$$

Momentum:

11. A 7,582 kilogram satellite is orbiting the Earth. At one point it is 3.35 x 10^7 meters away and traveling at a speed of 3,450 meters per second. At another point it is half the distance, 1.68 x 10^7 meters, away. Calculate the speed of the satellite at the second location.

$$L_b = L_a$$
$$\not{m}vr = \not{m}vr$$

$$v_a = \frac{v_b r_b}{r_a} = \frac{(3450\,\tfrac{m}{s})(3.35\times10^7\,m)}{(1.68\times10^7\,m)} = 6880\,\tfrac{m}{s}$$

Energy:

12. A pendulum is swinging back and forth with a period of 0.75 second. Calculate the length of the pendulum.

$$T = 2\pi\sqrt{\frac{L}{g}} \quad \text{so} \quad L = \left(\frac{T}{2\pi}\right)^2 g = \left(\frac{0.75s}{2\pi}\right)^2 9.81\,\tfrac{m}{s^2} = 0.14m$$

13. A 0.350 kg mass is attached to a spring which has a spring constant of 45 N/m, as shown. It is pulled down and released so that it bobs up and down. Calculate the period of the spring

$$T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{0.350kg}{45\,\tfrac{N}{m}}} = 0.55s$$

Thermodynamics Energy (the entire chapter):

14. The coldest temperature ever recorded in New York State was - 52.0 ^oF recorded in 1979 in Old Forge. Convert this temperature to Celsius and Kelvin.

$$T_C = \tfrac{5}{9}(T_F - 32.0) = \tfrac{5}{9}(-52.0 - 32.0) = -46.7°C$$

$$T_K = T_C + 273 = -46.7°C + 273 = 226K$$

15. A gas in a cylinder was placed in a heater and gained 5500. J of heat. The cylinder increased in volume from 345 mL to 1846 mL by the gas doing 150 J work on the environment. Calculate the change in internal energy of the gas in the cylinder.

$$\Delta U = Q + W = 5500.J + (-150J) = 5350J$$

16. There is an unknown quantity of gas at 1.2 x 10^5 Pa and a volume of 0.031 m^3 and a temperature of 87 ^oC. How many moles of gas is there?

$$PV = nRT$$

$$n = \frac{PV}{RT} = \frac{(1.2\times10^5 Pa)(0.031m^3)}{(8.31\,\tfrac{J}{mol\cdot K})(360K)} = 1.2mol$$

17. A gas has a volume of 3.0 x 10^{-4} m^3 at 4.0 x 10^4 Pa. Calculate the new volume if the pressure is changed to 8.0 x 10^4 Pa

$$\frac{P_1V_1}{\not{T}_1} = \frac{P_2V_2}{\not{T}_2}$$

$$V_2 = \frac{P_1V_2}{P_2} = \frac{(4.0\times10^4\text{Pa})(3.0\times10^{-4}\text{m}^3)}{8.0\times10^4\text{Pa}} = 1.5\times10^{-4}\text{m}^3$$

18. A 50 g container of nitrogen gas is at a temperature of 500. K. What is the average kinetic energy of the molecules in the gas?

$$\overline{KE} = \frac{3}{2}k_B T$$

$$\overline{KE} = \frac{3}{2}(1.38\times10^{-23}\,\tfrac{J}{K})(500.K)$$

$$\overline{KE} = 1.04\times10^{-20}\,J$$

Electrostatics:

19. Calculate the electric field at a distance of 6.2 x 10^{-8} meter away from an electron.

$$E = \frac{kq}{r^2} = \frac{\left(8.99\times10^{9}\,\frac{N\cdot m^2}{C^2}\right)\left(+1.60\times10^{-19}C\right)}{(6.2\times10^{-8}m)^2} = 3.7\times10^{5}\,\tfrac{N}{C}\text{ away from proton}$$

20. Two large, charged parallel plates are located 5.2 cm apart. The magnitude of the electric field between them is 455 N/C. Calculate the electric potential difference between the plates.

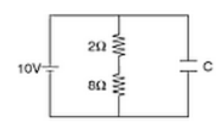
$$\Delta V = Ed = \left(455\,\tfrac{N}{C}\right)\left(0.052m\right) = 24\ V$$

21. A parallel plate capacitor has a charge of 9.0 μC when charged by a potential difference of 1.40 V. Calculate its capacitance.

$$C = \frac{Q}{V} = \frac{9.0\times10^{-6}C}{1.40V} = 6.4\times10^{-6}F$$

Electric Circuits:

22. A circuit is set up so a 2 ohm and an 8 ohm resistor are in series with each other and in parallel with a capacitor and a 10 volt cell, as shown.



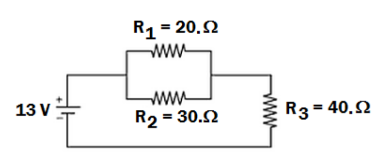
a. Determine the current in the 2 ohm resistor immediately after the battery is connected to the circuit.

An empty capacitor acts like a wire – in a parallel circuit it is a short circuit – current will not flow through the other segment – so there is no current through the 2 ohm resistor.

b. Determine the current in the 2 ohm resistor a long time later.

$$R_T = R_1 + R_2 = 2\Omega + 8\Omega = 10\Omega \qquad I = \frac{V}{R} = \frac{10V}{10\Omega} = 1A$$

23. A 13 volt cell is connected to three resistors, as shown.



a. Calculate the equivalent resistance of the circuit.

$$\text{PARALLEL}\quad \frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{20.\Omega} + \frac{1}{30.\Omega} \qquad R_{eq} = 12\Omega$$

$$\text{SERIES}\quad R_{eq} = R_1 + R_2 = 12\Omega + 40.\Omega = 52\Omega$$

b. Calculate the total current in the circuit.

$$I_t = \frac{V_t}{R_{eq}} = \frac{13V}{52\Omega} = 0.25A$$

c. Calculate the voltage across each resistor.

$$V_3 = I_3R_3 = (0.25\text{ A})(40.\ \Omega) = 10.\text{ V}$$

R3 is in series so it gets total current, use that to find V3

$$V_{1,2} = V_t - V_3 = 13\text{ V} - 10.\text{ V} = 3\text{ V}$$

$$\text{So } V_1 = 3\text{ V AND } V_2 = 3\text{V}$$

R1 and R2 get the remainder of battery, and have same amount because in parallel

d. Calculate the current through each resistor.

$$I_1 = \frac{V_1}{R_1} = \frac{3V}{20.\Omega} = 0.15A = 0.2A \qquad I_2 = \frac{V_2}{R_2} = \frac{3V}{30.\Omega} = 0.1A \qquad I_3 = I_T = 0.25A$$

Magnetism (almost the entire chapter):

24. A proton is traveling through a 41.2 Tesla magnetic field at a speed of 2.4 x 10^5 meters per second. Calculate the magnitude of the force acting on the proton.

$$F=qvB=(1.60\times10^{-19}\text{C})(2.4\times10^5\text{m/s})(41.2\text{ T}) = 1.6\times10^{-12}\text{ N}$$

25. A 9.5 centimeter current carrying wire is placed in a magnetic field with a strength of 5.1 T. It experiences a force of 0.78 N. Calculate the amount of current in the wire.

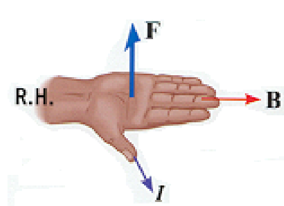
$$I=\frac{F_B}{B\ell}=\frac{0.78N}{(5.1T)(0.095m)}=1.6A$$

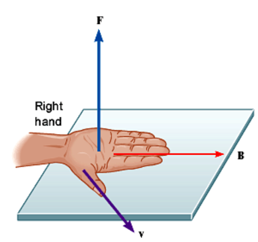
26. A 0.45 meter long wire is moved perpendicular to a 1.05 T magnetic field at a speed of 2.0 meters per second. Calculate the induced potential difference in the wire.

$$EMF=B\ell v=(1.05\text{ T})(0.45\text{m})(2.0\tfrac{m}{s})=0.95V$$

27. Know the hand rules for magnetic fields. Also know which hand is used for which type of charge.

The right hand is used for positive charges. The left hand is used for negative charges.





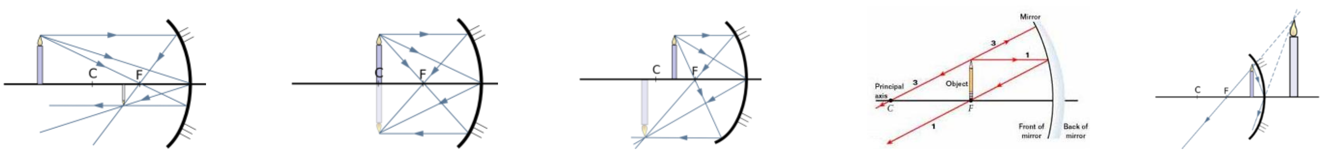
Waves/Reflection & Refraction:

28. A two-slit experiment is performed to measure the wavelength of a monochromatic light. The slits are 205 micrometers apart. A screen is placed 4.85 meters away and the separation between the central bright spot and the next bright spot is measured to be 21.4 millimeters. Calculate the wavelength of light.

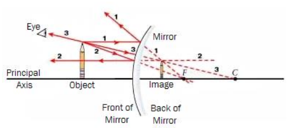
$$\lambda = \frac{dx}{\ell} = \frac{(205\times10^{-6}\ \text{m})(21.4\times10^{-3}\ \text{m})}{4.85\ \text{m}} = 9.05 \times 10^{-7}\ \text{m}$$

29. Know how to draw ray diagrams for both types of mirrors and both types of lenses.

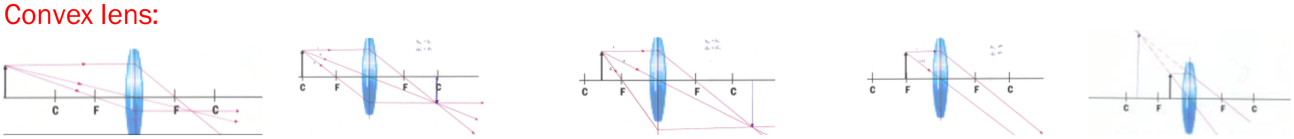
Concave mirror:



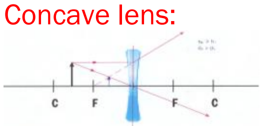
Convex mirror:



Convex lens:



Concave lens:



30. A 12.5 cm high object is placed 18.0 cm in front of a convex mirror with a radius of curvature of 64.5 cm. Calculate the location and size of the image. A convex mirror has a negative focal length.

$$\frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} \qquad \frac{1}{d_i} = \frac{1}{-32.3\text{cm}} - \frac{1}{18.0\text{m}}$$

$d_i = -11.6$ cm

$$h_i = \frac{-d_i\, h_o}{d_o} = \frac{-(-11.6cm)(12.5cm)}{18.0cm} = 8.06cm$$

31. A 12.5 cm high object is placed 32.0 cm in front of a concave mirror with a radius of curvature of 64.5 cm. Calculate the location and size of the image. A concave mirror has a positive focal length.

$$\frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} \qquad \frac{1}{d_i} = \frac{1}{32.3\text{cm}} - \frac{1}{18.0\text{m}}$$

$d_i = -40.7$ cm

$$h_i = \frac{-d_i\, h_o}{d_o} = \frac{-(-40.7cm)(12.5cm)}{18.0cm} = 28.3cm$$

32. A 7.5 cm object is placed 22 cm in front of a convex lens with a focal length of 18.5 cm. Calculate the location and size of the image. A convex lens has a positive focal length.

$$\frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} \qquad \frac{1}{d_i} = \frac{1}{18.5\text{cm}} - \frac{1}{22.0\text{m}}$$

$d_i = 116$ cm

$$h_i = \frac{-d_i\, h_o}{d_o} = \frac{-(116cm)(7.5cm)}{22cm} = -39.5cm$$

33. A 7.5 cm object is placed 22 cm in front of a concave lens with a focal length of 18.5 cm. Calculate the location and size of the image. A concave lens has a negative focal length.

$$\frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} \qquad \frac{1}{d_i} = \frac{1}{-18.5\text{cm}} - \frac{1}{22\text{m}}$$

d_i= -10.0 cm

$$h_i = \frac{-d_i\ h_o}{d_o} = \frac{-(-10.0cm)(7.5cm)}{22cm} = 3.4cm$$

Modern Physics:

34. Photons strike a metal surface with a work function of 2.1 eV, ejecting photoelectrons with a maximum kinetic energy of 7.5 eV. Calculate the energy of the photons.

$$KE = hf - \phi$$

$$E_{photon} = KE + \phi = 7.5eV + 2.1eV = 9.6eV$$

35. What is the momentum of an x-ray photon whose wavelength is 1.3 x 10^{-9} m?

$$p = \frac{h}{\lambda} = \frac{6.63 \times 10^{-34} J \bullet s}{1.3 \times 10^{-9} m} = 5.1 \times 10^{-25} \tfrac{kg \bullet m}{s}$$