Chapter 0.3 Discussion
Measurement, Uncertainty, Experiment Name: Kevin Lee

1. Rewrite the following equations in their clearest and most appropriate form, following the usual rules:

    1. Uncertainties should be rounded to one digit unless the first digit is a "1", in which case round to two digits.
    2. The measurement value should be rounded to the same decimal place as the uncertainty.
    3. A common power of ten and unit should be factored out of both the value and the uncertainty so that the value shows one nonzero digit before the decimal.

    (a) $v = 8.6711345 \pm 0.999864$ m/s $\quad$ $v = 9 \pm 1$ m/s

    (b) $x = 44278 \pm 2$ m $\quad$ $x = (4.4278 \pm 0.0002) \times 10^4$ m

    (c) $m = 7.7899 \times 10^{-7} \pm 3 \times 10^{-9}$ kg $\quad$ $m = (7.79 \pm 0.03) \times 10^{-7}$ kg

    (d) $q = 7.18 \pm 0.0143$ μC $\quad$ $q = 7.1800 \pm 0.0143$ μC

    (e) $\lambda = 45.78934 \times 10^{-2} \pm 5 \times 10^{-3}$ cm $\quad$ $\lambda = (4.58 \pm 0.05) \times 10^{-1}$ cm

(a) $v = 9 \pm 1$ m/s

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2. Use either maximum variation or quadrature propagation of uncertainty to simplify $A = (12 \pm 1) \times [(25 \pm 3) - (10 \pm 1)]$ to the form $A \pm \delta A$.

$A = 12 \times [25 - 10] = 180$

$\delta A = (12+1) \times [(25+3) - (10-1)] - 12 \times [25 - 10] = 67$

$\boxed{\therefore A \pm \delta A = 180 \pm 67}$

$\frac{29403}{4150}$ $\frac{5643}{800}$

3. Suppose we wish to calculate the momentum $p = mv$ of a mass. We measure m to be 0.247 kg on a scale whose smallest division is 1 g. The speed is found from two measurements of distance from the origin, $x_1 = 32.4$ cm and $x_2 = 91.8$ cm, both with a measuring tape marked in millimeters, and a measurement of a time interval $\Delta t = 2.08$ s, correct to within 0.005 s. Calculate $p \pm \delta p$.

$\boxed{\therefore p \pm \delta p = 7.05 \pm 0.03}$

$P = mv$

$P = m\frac{\Delta x}{\Delta t} = m\frac{x_2 - x_1}{\Delta t}$

$= 0.247\text{kg}\,\frac{91.8-32.4}{2.08} = 7.05375$

$m = 0.247\text{kg}$ $\quad \delta m = 0.0005\text{kg}$

$x_1 = 32.4\text{cm}$ $\quad \delta x_1 = 0.05\text{cm}$

$x_2 = 91.8\text{cm}$ $\quad \delta x_2 = 0.05\text{cm}$

$\Delta t = 2.08\text{s}$ $\quad \delta \Delta t = 0.005\text{s}$

$\delta P = 7.085060241 - 7.05375$

$= 0.031310241$

$$\delta P = P_{max} - P = (m \pm \delta m)\frac{(x_2+\delta x_2) - (x_1 - \delta x_1)}{\Delta t - \delta\Delta t} - m\frac{x_2 - x_1}{\Delta t}$$

$$P_{max} = (0.247 + 0.0005\text{kg})\frac{(91.8+0.05)\text{m} - (32.4-0.05)\text{m}}{(2.08 - 0.005)\text{s}} - 0.247\text{kg}\,\frac{(91.8-32.4)\text{m}}{2.08\text{s}}$$

4. The figure on the next page shows an apparatus used to measure rotational inertias of various objects, in this case spheres of varying masses M and radii R. The spheres are made of different materials, and some are hollow while others are solid.

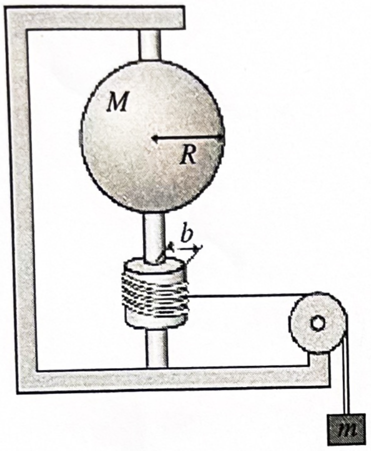
   To perform the experiment, a sphere is mounted to a vertical axle held in a frame with essentially frictionless bearings. A spool of radius $b = 2.50$ cm is also mounted to the axle, and a string is wrapped around the spool. The string runs horizontally over an essentially frictionless pulley and is tied to a mass $m = 77.8$ g. As the mass falls, the string imparts a torque to the spool/axle/disk combination, resulting in angular acceleration. The mass of the string is negligible, but the combination of axle and spool has nonnegligible rotational inertia I_0 whose value isn't known in advance.

   In each experimental run, the mass m is suspended a height $h = 1.00$ m above the floor and the rotating system is initially at rest. The mass is released, and experimenters measure the time to reach the floor. Results are given in the tables below for ten runs (half are solid spheres and half are hollow, but we don't know which are which!). Using kinematics and Newton's 2nd Law, you will determine later in this course the appropriate function of the time t which, when plotted against other quantities including M and R, should yield two straight lines - one for the hollow spheres and one for the solid ones. For now, the answer is given:

$$\frac{mgb^2}{2h}t^2 = \beta MR^2 + I_0 + mb^2,$$

where $I = \beta M R^2$ is the moment of inertia of the sphere and β is a dimensionless number that depends on the mass distribution in the sphere.

Plot your data and establish best-fit lines (hint: sort by MR^2 and highlight the cells that belong to each line with different colors, then re-create the plot with two data series). Use the resulting slopes to verify that the rotational inertia of a solid sphere is $I_s = \frac{2}{5}MR^2$ and that of a hollow sphere is $I_h = \frac{2}{3}MR^2$. You should also find a value for the rotational inertia I_0 of the axle and spool together.



$b = 2.50\,\text{cm}$

$m = 77.8\,\text{g}$

$h = 1.00\,\text{m}$

$I = \beta M R^2$

$$\frac{mgb^2}{2h}t^2 = \beta M R^2 + I_0 + mb^2$$

Sphere mass M (g)	783	432	286	677	347	947	189	821	544	417
Sphere radius R (cm)	6.25	3.86	9.34	9.42	9.12	6.71	5.45	6.55	4.67	9.98
Fall time t (s)	2.36	1.22	2.72	3.24	2.91	2.75	1.41	2.51	1.93	3.47

$$\frac{(77.8)(9.8)(2.50)^2}{2\times(1.00\,\text{m})}(2.36)^2 = \beta(783)(6.25)^2 + I_0 + (77.8)(2.50)^2$$

$$13270.2682 = \beta(30585.9375) + I_0 + 486.25$$

$\frac{1}{2}at^2 = h$

$$12784.0182 = \beta(30585.9375) + I_0$$

I did plot the data to excel and came out with two lines one for Solid and one anothe for the hollow

I know the $mg - T = ma$, the weight minus string Force is total F. also the time is $\sqrt{\frac{2h}{g}}$ because of $y = \underset{0}{y_0} + \underset{0}{V_{y_0}}t + \frac{1}{2}\underset{g}{a}t^2$