

1 - Measurement

PJ Gibson - Peace Corps Tanzania

May 2020

1 Measurement

1.1 Physical Quantities

- (1999) Mention two applications and two limitations of dimensional analysis.
- (1999) The frequency f of a note produced by a taut wire stretched between two supports depends on the distance l between the supports, the mass per unit length of the wire, μ , and the tension T . Use dimensional analysis to find how f is related to l , μ , and T .
- (1999) The period T of vibrations of a tuning fork may be expected to depend on the density D , Young's Modulus Y of the material of which it is made and the length a of its prongs. Using dimensional analysis deduce an expression for T in terms of D , Y and a .
- (2000) The speed v of a wave is found to depend on the tension T in the string and the mass per unit length u (linear mass density). Using dimensional analysis derive the relationship between v , T and u .
- (2007) Mention two(2) uses of dimensional analysis.
- (2007) The frequency f of a note given by an organ pipe depends on the length, l , the air pressure P and the air density D . Use the method of dimensions to find a formula for the frequency.
 - What will be the new frequency of a pipe whos original frequency was 256 Hz if the air density falls by 2% and the pressure increases by 1% ?
- (2010) Mention two uses of dimensional analysis.
- (2010) The critical velocity of a liquid flowing in a certain pipe is 3 m/s, assuming that the critical velocity v depends on the density ρ of the liquid. its viscosity μ , and the diameter d of the pipe.
 - Use the method of dimensional analysis to derive the equation of the critical velocity of the liquid in a pipe of half the diameter.
 - Calculate the value of critical velocity.
- (2014) What is the importance of dimensional analysis inspite of its drawbacks?
- (2015) State the law of dimensional analysis.

- (2015) The largest mass, m of a stone that can be moved by the flowing river depends on the velocity of flow v , the density ρ of water, and the acceleration due to gravity g . Show that the mass, m varies to the sixth power of the velocity of flow.
- (2016) Define the term dimension of a physical quantity.
- (2016) Give two basic rules of dimensional analysis.
- (2016) The frequency, f of a vibrating string depends upon the force applied, F , the length, l , of the string and the mass per unit length, μ . Using dimension show how f is related to F , l and μ .
- (2016) What is meant by least count of a measurement?
- (2017) Define the term dimensions of a physical quantity.
- (2017) Identify two uses of dimensional equations.
- (2017) What is the basic requirement for a physical relation to be correct?
- (2017) List two quantities whose dimension is $[ML^2T^{-1}]$
- (2017) The frequency f of vibration of a stretched string depends on the tension F , the length l and the mass per unit length μ of the string. Derive the formula relating the physical quantities by the method of dimensions.
- (2017) Use dimensional analysis to prove the correctness of the relation, $\rho = \frac{3g}{4\pi RG}$ where by ρ = density of the earth, g = acceleration due to gravity, R = radius of the earth and G = gravitational constant.
- (2018) State the law of dimensional analysis.
- (2018) If the speed v of the transverse wave along a wire of tension, T and mass, m is given by, $V = \sqrt{T/m}$. Apply dimensional analysis to check whether the given expression is correct or not.
- (2019) Identify two basic rules of dimensional analysis.
- (2019) The frequency n of vibration of a stretched string is a function of its tension F , the length, l and mass per unit length m . Use the method of dimensions to derive the formula relating the stated physical quantities.

1.2 Errors

- (2000) What is an error? Mention two causes of systematic and two causes of random errors.
- (2000) The pressure P is calculated from the relation $P = F/(\pi R^2)$ where F is the force and R the radius. If the percentage possible errors are +2% for F and +1% for R . Calculate the possible percentage error for P .
- (2007) What is systematic error?
- (2007) The smallest divisions for the voltmeter and ammeter are 0.1 V and 0.01 A respectively. If $V = IR$, find the relative error in the resistance R , when $V = 2$ V and $I = 0.1$ A.

- (2010) Define an error.
- (2010) In an experiment to determine the acceleration due to gravity g , a small ball bearing is timed while falling freely from rest through a measured vertical height. The following data were obtained: vertical height $h = (600 \pm 1)$ mm, time taken $t = (350 \pm 1)$ ms. Calculate the numerical value of g from the experimental data, clearly specify the errors.
- (2013) What is the difference between degree of accuracy and precision.
- (2013) In an experiment to determine Young's modulus of a wooden material the following measurements were recorded:
 - length $l = 80.0 \pm 0.05$ cm
 - breadth $b = 28.65 \pm 0.03$ mm
 - thickness $t = 6.40 \pm 0.03$ mm and
 - slope $G = 0.035 \pm 0.001$ cm/gm
 - Given that the Young's modulus Y is given by:
 - $Y = (4/Gb)(l/t)^3$
 - Calculate the maximum percentage error in the value of Y .
- (2014) Distinguish random error from systematic error.
 - Give a practical example of random error and systematic error and briefly explain how they can be reduced or eliminated.
- (2014) Define the terms error and mistake.
- (2014) An experiment was done to find the acceleration due to gravity by using the formula: $T = 2\pi\sqrt{l/g}$, where all symbols carry their usual meaning. If the clock losses 3 seconds in 5 minutes, determine the error in measuring g given that, $T = 2.22$ sec, $l = 121.6$ cm, $\Delta T_1 = 0.1$ sec, and $\Delta l = \pm 0.05$.
- (2014) The following measurements were taken by a student for the length of a piece of rod: 21.02, 20.99, 20.92, 21.11 and 20.69. Basing on error analysis find the true value at the length of a piece of rod and its associated error.
- (2015) What is meant by random errors?
 - Briefly explain two causes of random errors in measurements.
- (2015) The period T of oscillation of a body is said to be 1.5 ± 0.002 s while its amplitude A is 0.3 ± 0.005 m and the radius of gyration k is 0.28 ± 0.004 m. If the acceleration due to gravity g was found to be related to T , A and k by the equation $(gA)/(4\pi^2) = (A^2 + k^2)/T^2$, find the:
 - Numerical value of g in four decimal places
 - Percentage error in g .
- (2016) The period of oscillation of a simple pendulum is given by $T = 2\pi\sqrt{l/g}$ where by 100 vibrations were taken to measure 200 seconds. If the least count for the time and length of a pendulum of 1 m are 0.1 sec and 1 mm respectively, calculate the maximum percentage error in the measurement of g .

- (2017) Give the meaning of the following terms as used in error analysis:
 - Absolute error.
 - Relative error.
- (2017) The force F acting on an object of mass m , travelling at velocity v in a circle of radius r is given by: $F = \frac{mv^2}{r}$. If the measurements are recorded as: $m = (3.5 \pm 0.1)$ kg, $V = (20 \pm 1)$ m/s, $r = (12.5 \pm 0.5)m$; find the maximum possible
 - Fractional error.
 - Percentage error in the measurement of force.
 - Show how you will record the reading of force, F in the question above.
- (2018) How can random and Systematic errors be minimized during an experiment?
- (2018) Estimate the precision to which the Young's modulus, γ of the wire can be determined from the formula $\gamma = (4Fl)/(\pi d^2e)$, given that the applied tension, $F = 500$ N, the length of the loaded wire, $l = 3$ m, the diameter of the wire, $d = 1$ mm, the extension of the wire, $e = 5$ mm and the errors associated with these quantities are 0.5 N, 2 mm, 0.01 mm and 0.1 mm respectively.
- (2019) What causes systematic errors in an experiment? Give four points.
- (2019) Estimate the numerical value of drag force $D = 1/2C\rho AV^2$ with its associated error given that the measurements of the quantities C , A , ρ and v were recorded as (10 ± 0.00) unit less, (5 ± 0.2) cm², (15 ± 0.15) g/cm³ and (3 ± 0.5) cm/sec² respectively.