Units and Measurements

1. The errors in the measurement which arise due to unpredictable fluctuations in temperature and voltage supply are: **(2023)**
   (a) Random errors
   (b) Instrumental errors
   (c) Personal errors
   (d) Least count errors

2. A metal wire has mass (0.4 ± 0.002) g, radius (0.3 ± 0.001) mm and length (5 ± 0.02) cm. The maximum possible percentage error in the measurement of density will nearly be : **(2023)**
   (a) 1.4%
   (b) 1.2%
   (c) 1.3%
   (d) 1.6%

3. The area of a rectangular field (in m^2) of length 55.3 m and breadth 25 m in after rounding off the value for correct significant digit is: **(2022)**
   (a) 1.38×10^1
   (b) 1382
   (c) 1382.5
   (d) 14×10^2

4. The dimensions $[MLT^{-2}A^{-2}]$ belong to the: **(2022)**
   (a) magnetic flux
   (b) sell inductance
   (c) magnetic permeability
   (d) electric permittivity

5. Plane angle and solid angle have **(2022)**
   (a) Units but no dimensions
   (b) Dimensions but no units
   (c) No units and no dimensions
   (d) Both units and dimensions

6. If E and G respectively denote energy and gravitational constant, then E/G has the dimensions of **(2021)**
   (a) $[M][L^{-1}][T^{-1}]$
   (b) $[M][L^{0}][T^{0}]$
   (c) $[M^2]\,[L^{-2}][T^{-1}]$
   (d) $[M^2]\,[L^{-1}][T^{0}]$

7. A screw gauge gives the following readings when used to measure the diameter of a wire **(2021)**
   Main scale reading : 0 mm
   Circular scale reading : 52 divisions
   Given that 1 mm on main scale corresponds to 100 divisions on the circular scale. The diameter of the wire from the above data is:
   (a) 0.026 cm
   (b) 0.26 cm
   (c) 0.052 cm
   (d) 0.52 cm

8. If force [F], acceleration [A] and time [T] are chosen as the fundamental physical quantities. Find the dimensions of energy. **(2021)**
   (a) $[F][A][T^2]$
   (b) $[F][A][T^{-1}]$
   (c) $[F][A^{-1}][T]$
   (d) $[F][A][T]$

9. A screw gauge has least count of 0.01 mm and there are 50 divisions in its circular scale. The pitch of the screw gauge is: **(2020)**
   (a) 0.25 mm
   (b) 0.5 mm
   (c) 1.0 mm
   (d) 0.01 mm

10. Taking into account of the significant figures, what is the value of 9.99 m – 0.0099 m? **(2020)**
    (a) 9.98 m
    (b) 9.980 m
    (c) 9.9 m
    (d) 9.9801 m

11. Dimensions of stress are : **(2020)**
    (a) $[ML^2T^{-2}]$
    (b) $[ML^0T^{-2}]$

(c) $[ML^{-1}T^{-2}]$
(d) $[MLT^{-2}]$

12. The intervals measured by a clock given the following readings:
1.25 s, 1.24 s, 1.27 s, 1.21 s and 1.28 s. What is the percentage relative error is the observations? **(2020 Covid Re-NEET)**
(a) 4%
(b) 16%
(c) 1.6%
(d) 2%

13. The angle of 1' (minute of arc) in radian is nearly equal to **(2020 Covid Re-NEET)**
(a) 4.85×10^{-4} rad
(b) 4.80×10^{-6} rad
(c) 1.75×10^{-2} rad
(d) 2.91×10^{-4} rad

14. In an experiment, the percentage of error occurred in the measurement of physical quantities A, B, C and D are 1%, 2%, 3% and 4% respectively. Then the maximum percentage of error in the measurement of X, **(2019)**
Where $X = \frac{A^2B^{\frac{1}{2}}}{C^{\frac{1}{3}}D^3}$ will be
(a) $\left(\frac{3}{10}\right)\%$
(b) 16 %
(c) -10 %
(d) 10 %

15. A student measured the diameter of a small steel ball using a screw gauge of least count 0.001 cm. The main scale reading is 5 mm and zero of circular scale division coincides with 25 divisions above the reference level. If screw gauge has a zero error of –0.004 cm, the correct diameter of the ball is **(2018)**
(a) 0.053 cm
(b) 0.525 cm
(c) 0.521 cm
(d) 0.529 cm

16. A physical quantity of the dimensions of length that can be formed out of c, G and $\frac{e^2}{4\pi\varepsilon_0}$ is [c is velocity of light, G is universal constant of gravitation and e is charge]: **(2017)**
(a) $c^2\left[G\frac{e^2}{4\pi\varepsilon_0}\right]^{1/2}$
(b) $\frac{1}{c^2}\left[\frac{e^2}{G4\pi\varepsilon_0}\right]^{1/2}$
(c) $\frac{1}{c^2}G\frac{e^2}{G4\pi\varepsilon_0}$
(d) $\frac{1}{c^2}\left[G\frac{e^2}{4\pi\varepsilon_0}\right]^{1/2}$

17. A student performs an experiment of measuring the thickness of a slab with a vernier caliper whose 50 divisions of the main scale. He noted that zero of the vernier scale is between 7.00 cm and 7.05 cm mark of the main scale and 23rd division of the vernier scale exactly coincides with the main scale. The measured value of the thickness of the given slab using the caliper will be: **(2017)**
(a) 7.73 cm
(b) 7.23 cm
(c) 7.023 cm
(d) 7.073 cm

18. Planck's constant (h), speed of light in vacuum (c) and Newton's gravitational constant (G) are three fundamental constants. Which of the following combinations of these has the dimension of length? **(2016 - II)**
(a) $\sqrt{\frac{hc}{G}}$
(b) $\sqrt{\frac{Gc}{h^{3/2}}}$
(c) $\sqrt{\frac{hG}{c^{3/2}}}$
(d) $\sqrt{\frac{hG}{c^{5/2}}}$

19. If energy (E), velocity (V) and time (T) are chosen as the fundamental quantities, the dimensional formula of surface tension will be: **(2015)**
(a) $[EV^{-1}T^{-2}]$
(b) $[EV^{-2}T^{-2}]$
(c) $[E^{-2}V^{-1}T^{-3}]$
(d) $[EV^{-2}T^{-1}]$

20. If dimension of critical velocity of liquid flowing through a tube are expressed as vc

$\propto[\eta x \rho y r z]$ where η, ρ and r are the coefficient of viscosity of liquid, density of liquid and radius of the tube respectively, then the values of x, y and z are given by: **(2015 - Re)**

(a) 1,1,1
(b) 1, −1, −1
(c) −1, −1, 1
(d) −1, −1, −1

21. If Force (F), Velocity (V) and Time (T) are taken as fundamental units, then the dimensions of mass are: **(2014)**

(a) $[F\,V\,T^{-1}]$
(b) $[F\,V\,T^{-2}]$
(c) $[F\,V^{-1}\,T^{-1}]$
(d) $[F\,V^{-1}\,T]$

22. In an experiment four quantities a, b, c and d are measured with percentage error 1%, 2%, 3% and 4% respectively. Quantity P is calculated as follows $P = \frac{a^3b^2}{cd}$. % error in P is: **(2013)**

(a) 4%
(b) 14%
(c) 10%
(d) 7%

Answer Key

S1. Ans. (a)

S2. Ans. (d)

S3. Ans. (d)

S4. Ans. (c)

S5. Ans. (a)

S6. Ans. (d)

S7. Ans. (c)

S8. Ans. (a)

S9. Ans. (b)

S10. Ans. (a)

S11. Ans. (c)

S12. Ans. (c)

S13. Ans. (d)

S14. Ans. (b)

S15. Ans. (d)

S16. Ans. (d)

S17. Ans. (c)

S18. Ans. (c)

S19. Ans. (b)

S20. Ans. (b)

S21. Ans. (d)

S22. Ans. (b)

Soluiton

S1. Ans. (a)
As the factors controlling temperature and voltage supply are beyond prediction and control so the error occurred due to unpredictable fluctuations of temperature and voltage would be random errors.

S2. Ans. (d)
$m = \rho\pi r^2 l$
$\rho = \dfrac{m}{\pi r^2 l}$
$\dfrac{\Delta\rho}{\rho} = \dfrac{\Delta m}{m} + \dfrac{2\Delta r}{r} + \dfrac{\Delta l}{l}$
$\dfrac{\Delta\rho}{\rho} \times 100 = \dfrac{0.002}{0.4} \times 100 + \dfrac{2 \times 0.001}{0.3} \times 100 + \dfrac{0.02}{5} \times 100$
$= \dfrac{0.2}{0.4} + \dfrac{0.2}{0.3} + \dfrac{2}{5}$
$= 0.5 + 0.67 + 0.4$
$= 1.57$
$= 1.6\%$

S3. Ans. (d)
Given, that, length $(l) = 55.3\ m$
Breadth $(b) = 25\ m$
The area of rectangular field is, $A = l \times b = 55.3 \times 25$
$= 1382.5\ m^2 = 1.3825 \times 10^3 m^2 = 1.4 \times 10^3 = 14 \times 10^2$.

S4. Ans. (d)
Dimensions of magnetic flux $= [ML^2T^{-2}A^{-1}]$
Dimensions of self-inductance $= [ML^2T^{-2}A^{-2}]$
Dimensions of magnetic permeability $= [MLT^{-2}A^{-2}]$
Dimensions of electrical permittivity $= [M^{-1}L^{-3}T^4A^2]$
So, the correct option is (c)

S5. Ans. (a)
Plane angle and solid angle have supplementary units. Radian (rad) is the unit ot plane angle and steradian (sr) is the unit of solid angle Plane angle and solid angle are dimensionless quantities.

S6. Ans. (d)
Hint: E = Energy = $[ML^2T^{-2}]$
G = Gravitational constant
$= [M^{-1}L^3T^{-2}]$
So, $\dfrac{E}{G} = \dfrac{[E]}{[G]} = \dfrac{ML^2T^{-2}}{M^{-1}L^3T^{-2}} = [M^2L^{-1}T^0]$

S7. Ans. (c)
Hint: L.C. $= \dfrac{\text{Pitch}}{\text{CSD}}$
$= \dfrac{1\text{mm}}{100} = 0.01$ m $= 0.001$ cm
Radius = M.S. + n(L.C.)
= 0 + 52 (0.001)
= 0.052 cm

S8. Ans. (a)
Hint: $E \propto F^a A^b T^c$
$[M^1L^2T^{-2}] \propto [M^1L^{-2}]^a [LT^{-2}]^b [T^c]$
$a = 1$
$a + b = 2 \Rightarrow b = 1$
$-2a - 2b + c = -2$
$\Rightarrow c = 2$
$a = 1\ b = 1\ c = 2$
$E \propto [F]\ [A]\ [T^{+2}]$

S9. Ans. (b)
Hint: Least count
$= \dfrac{\text{Pitch}}{\text{Number of divisions on circular scale}}$
$\Rightarrow 0.01\text{ mm} = \dfrac{\text{Pitch}}{50}$
$\Rightarrow$ pitch $= 0.5$ mm

S10. Ans. (a)
Hint:
In subtraction the number of decimal places in the result should be equal to the number of decimal places of that term in the operation which contain lesser number of decimal places.

S11. Ans. (c)
Hint:
Stress $= \dfrac{\text{Force}}{\text{Area}}$
$= \dfrac{M^1L^1T^{-2}}{L^2}$
Stress $= M^1L^{-1}T^{-2}$

S12. Ans. (c)
Hint: Mean of given observations
$= \dfrac{1.25 + 1.24 + 1.27 + 1.21 + 1.28}{5} = 1.25$ sec
Mean of errors
$= \dfrac{0 + 0.01 + 0.02 + 0.04 + 0.03}{5}$
$= \dfrac{0.1}{5}$
% error $= \dfrac{0.1 \times 100}{5 \times 1.25} = 1.6\%$

S13. Ans. (d)

Hint: 1 minute of arc= $1' = \left(\frac{1}{60}\right)^0 = \frac{1}{60} \times \frac{\pi}{180}$ radian
$= 2.91 \times 10^{-4}$ radian.

S14. Ans. (b)

Hint: $X = \frac{A^2 B^{\frac{1}{2}}}{C^{\frac{1}{3}} D^3}$
% error, $\frac{\Delta X}{X} \times 100$
$= 2\frac{\Delta A}{A} \times 100 + \frac{1}{2}\frac{\Delta B}{B} \times 100 + \frac{1}{3}\frac{\Delta C}{C} \times 100 +$
$3\frac{\Delta D}{D} \times 100$
$= 2\% + 1\% + 1\% + 12\%$
$= 16\%$

S15. Ans. (d)
Hint: Reading = MSR + (n × LC) + zero error
$= 0.5 + (25 \times 0.001) + 0.004$
$= 0.529$ cm

S16. Ans. (d)
Hint: $[c]^a[G]^b\left[\frac{e^2}{4\pi\varepsilon_0}\right]^c$
$= [LT^{-1}]^a[M^{-1}L^3T^{-2}]^b[ML^3T^{-2}]^c$
$= L^{a+3b+3c}\ T^{-a-2b-2c}\ M^{-b+c}$
$a + 3b + 3c = 1;\ -a - 2b - 2c$
$= 0;\ -b + c = 0$
$b = \frac{1}{2} \qquad c = \frac{1}{2}$
$a = -2$
$L = c^{-2}G^{\frac{1}{2}\left[\frac{e^2}{4\pi\varepsilon_0}\right]^{\frac{1}{2}}}$
$L = \frac{1}{c^2}\left[G\left[\frac{e^2}{4\pi\varepsilon_0}\right]^{\frac{1}{2}}\right]$

S17. Ans. (c)
Hint: Least count = 1MSD – 1VSD
$= 5 \times 10^{-2} - \frac{49}{50} \times 5 \times 10^{-2}$
Thickness = $7 + 23 \times 10^{-3} = 7.023$ cm

S18. Ans. (c)
Hint: $\ell \propto h^x G^y c^z$
$M^0L^1T^0 = (ML^2T^{-1})^x(M^{-1}L^3T^{-2})^y(LT^{-1})^z$
$M^{x-y}L^{2x+3y+z}T^{-x-2y-z}$
Equating:
$\left.\begin{matrix} x - y = 0 \\ 2x + 3y + z = 1 \\ -x - 2y - z = 0 \end{matrix}\right\}$
$\Rightarrow x = \frac{1}{2}; y = \frac{1}{2}; z = -\frac{3}{2}$
$\Rightarrow \ell \propto \sqrt{\frac{hG}{c^{\frac{3}{2}}}}$

S19. Ans. (b)
Hint: S.T $[E]^a\ [V]^b\ [T]^c$
$\propto [ML^{-2}T^{-2}]^a[LT^{-1}]^b[T]^c$
$MT^{-2} \propto M^aL^{2a+b}\ T^{-2a+b+c}$
On comparing both sides.
$2a + b = 0$, $-2a - b + c = -2$
$a = 1$, $b = -2$, $c = -2$
we get
$ST = EV^{-2}\ T^{-2}$

S20. Ans. (b)
Hint: $v_c \propto [\eta^x \rho^y r^z]$
$[L^1T^{-1}] \propto [M^1L^{-1}T^{-1}]^x[M^1L^{-3}]^y[L^1]^z$
$[L^1T^{-1}] \propto [M^{x+y}][L^{-x-3y+z}][T^{-x}]$
Taking comparison on both size
$x + y = 0$, $-x - 3y + z = 1$, $-x = -1$
$x = 1$, $y = -1$, $z = -1$

S21. Ans. (d)
Hint: $[\text{Mass}] = \left[\frac{\text{Force}}{\text{Accleration}}\right] = \left[\frac{\text{Force}}{\text{Velocity/time}}\right]$
$= [FV^{-1}T]$

S22. Ans. (b)
Hint: $P = \frac{a^3b^2}{cd} \Rightarrow \frac{\Delta P}{P}$
$= \pm\left(3\frac{\Delta a}{a} + 2\frac{\Delta b}{b} + \frac{\Delta c}{c} + \frac{\Delta d}{d}\right)$
$= \pm(3 \times 1 + 2 \times 2 + 3 + 4) \Rightarrow \pm 14\%$