

Dan Dumitru

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APPLIED ANALYTICS

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1. Write down the base units for the following:

- a) Temperature
- b) Luminous Intensity
- c) Volume
- d) Displacement
- e) Time

Answers:

- a) Temperature - Base unit: Kelvin (K)
- b) Luminous Intensity - Base unit: Candela (cd)
- c) Volume – Base Unit: Its base units are cubic meters (m^3)
- d) Displacement – Base unit: Meter (m)
- e) Time – Base unit: Second (s)

2. Given that pressure is defined as:

$$\text{Pressure} = \text{Force} / \text{Area}$$

Write down the *base units* of Pressure.

The formula for pressure is :

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

1. Force is defined as $\text{mass} \times \text{acceleration}$:

$$\text{Force} = \text{kg} \cdot \text{m} / \text{s}^2$$

Its base unit is $\text{kg} \cdot \text{m} / \text{s}^2$.

2. Area is defined by $\text{length} \times \text{length}$:

$$\text{Area} = \text{m}^2$$

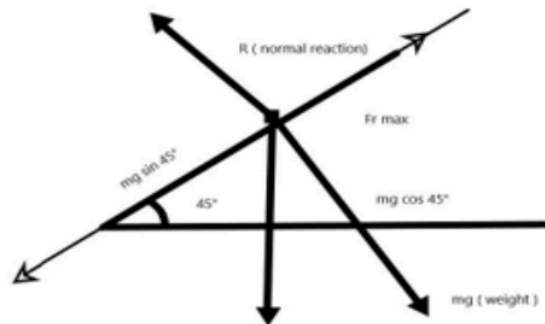
Its base unit is m^2 .

3. Pressure is force divided by area :

$$\text{Pressure} = \frac{\text{kg} \cdot \text{m} / \text{s}^2}{\text{m}^2} = \text{kg} \cdot \text{m}^{-1} \text{s}^{-2}$$

Base units of pressure : $\text{kg} \cdot \text{m}^{-1} \text{s}^{-2}$

3. A body of mass 2kg rests in limiting equilibrium on a rough inclined plane, which is at an angle of 45° to the horizontal.
- Draw a free body diagram in your answer booklet showing the frictional force, normal reaction and the component of weight that acts down the slope.
 - Calculate the maximum magnitude of frictional force.
 - State which of the other forces are equal and give a reason why you can state this without calculation.
 - Calculate the magnitude of the normal reaction to the surface.



b) Calculate the maximum magnitude of frictional force.

The frictional force equals the component of the weight parallel to the slope

$$F = mg \sin 45^\circ$$

Values

$$M = 2 \text{ kg}$$

$$g = 9.8 \text{ m/s}^2 \text{ (approximate acceleration due to gravity near the Earth's surface)}$$

$$\cos 45^\circ = \frac{1}{\sqrt{2}} \approx 0.707$$

$$F = 2 \cdot 9.8 \cdot 0.707 \approx 13.86 \text{ N}$$

$$F \approx 13.86 \text{ N}$$

c) State which of the other forces are equal and give a reason why you can state this without calculation.

1. The frictional force (F) equals the component of weight down the slope ($mg \sin 45^\circ$) because the body is in limiting equilibrium (no acceleration).

2. The normal reaction (R) equals the component of weight perpendicular to the slope ($mg \cos 45^\circ$) because there is no vertical motion perpendicular to the plane.

d) Calculate the magnitude of the normal reaction to the surface.

The normal reaction (R) balances the perpendicular component of weight

$$R = mg \cos 45^\circ$$

Values

$$M = 2 \text{ kg}$$

$$g = 9.8 \text{ m/s}^2 \text{ (approximate acceleration due to gravity near the Earth's surface)}$$

$$\sin 45^\circ = \frac{1}{\sqrt{2}} \approx 0.707$$

$$R = 2 \cdot 9.8 \cdot 0.707 \approx 13.86 \text{ N}$$

$$R \approx 13.86N$$

Solve the following by factorising:

1) $x^2 - 5x + 6 = 0$

2) $x^2 + 7x + 6 = 0$

3) $x^2 + 10x = -25$

4) $x^2 - 2x - 15 = 0$

5) $2x^2 + 3x + 1 = 0$

Answer:

1) $x^2 - 5x + 6 = 0$

$$(-2) \times (-3) = 6 \text{ and } (-2) + (-3) = -5$$

$$x^2 - 5x + 6 = x^2 - 2x - 3x + 6$$

$$(x^2 - 2x) - (3x - 6) = 0$$

$$x(x - 2) - 3(x - 2) = 0$$

$$x - 2 = 0 \Rightarrow x = 2$$

$$x - 3 = 0 \Rightarrow x = 3$$

Solutions

$$x = 2 \quad x = 3$$

2) $x^2 + 7x + 6 = 0$

$$1 \times 6 = 6 \text{ and } 1 + 6 = 7$$

$$x^2 + 1x + 6x + 6 = 0$$

$$(x^2 + 1x) + (6x + 6) = 0$$

$$(x + 1)(x + 6) = 0$$

$$x + 1 = 0 \Rightarrow x = -1$$

$$x + 6 = 0 \Rightarrow x = -6$$

$$x = -1$$

$$x=-6$$

$$3) \mathbf{x^2+10x=-25}$$

$$x^2+10x+25=-25+25$$

$$a=1 \ b=10 \ c=25$$

$$5 \times 5=25 \text{ and } 5+5=10$$

$$x^2+5x+5x+25=0$$

$$(x^2+5x) + (5x+25) = 0$$

$$(x+5)(x+5)=0$$

$$x+5=0 \Rightarrow x=-5$$

$$x=-5$$

$$4) \mathbf{x^2-2x-15=0}$$

$$(-5) \times 3=-15 \ \& \ (-5) + 3=-2$$

$$x^2-5x+3x-15=0$$

$$(x^2-5x) + (3x-15) = 0$$

$$x(x-5) + 3(x-5) = 0$$

$$(x-5)(x+3) = 0$$

$$x-5=0 \Rightarrow x=5$$

$$x+3=0 \Rightarrow x=-3$$

$$x=5$$

$$x=-3$$

$$5) \mathbf{2x^2+3x+1=0}$$

$$a=2, \ b=3, \ c=1$$

$$2 \times 1 = 2$$

$$1 \times 2 = 2 \text{ and } 1+2=3$$

$$2x^2 + 1x + 2x + 1 = 0$$

$$(2x^2 + 1x) + (2x+1) = 0$$

$$x(2x+1) + 1(2x+1) = 0$$

$$(2x+1)(x+1) = 0$$

$$2x+1=0 \Rightarrow x = -\frac{1}{2}$$

$$x+1=0 \Rightarrow x = -1$$

$$x = -\frac{1}{2}$$

$$x = -1$$

5. Solve the following (to 2d.p's) by using the quadratic formula:

$$1. x^2 - 4x - 1 = 0$$

$$2. 2x^2 + 3x - 1 = 0$$

Answer:

$$1. x^2 - 4x - 1 = 0$$

$$a=1, b=-4, c=-1,$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \quad x = \frac{-(-4) \pm \sqrt{4^2 - 4 \cdot 1 \cdot (-1)}}{2 \cdot 1} \quad x = \frac{4 \pm \sqrt{16 + 4}}{2} \quad x = \frac{4 \pm \sqrt{20}}{2}$$

$$x = \frac{4 + \sqrt{20}}{2} \Rightarrow \sqrt{20} \approx 4.472 \Rightarrow x = \frac{4 + 4.472}{2} \approx 4.24$$

$$x = \frac{4 - \sqrt{20}}{2} \Rightarrow \sqrt{20} \approx 4.472 \Rightarrow x = \frac{4 - 4.472}{2} \approx -0.24$$

Solutions

$$1. x \approx 4.24$$

$$2. x \approx -0.24$$

$$2. 2x^2 + 3x - 1 = 0$$

$$a=2, b=3, c=-1, x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \quad x = \frac{-3 \pm \sqrt{3^2 - 4 \cdot 2 \cdot (-1)}}{2 \cdot 2}$$

$$x = \frac{-3 \pm \sqrt{9 + 8}}{4} \Rightarrow x = \frac{-3 \pm \sqrt{17}}{4}$$

positive square root

$$\sqrt{17} \approx 4.12$$

$$x = -3 + 4.124 \approx 1.124 \approx 0.28$$

$$\text{negative square root } x = -3 - \sqrt{174} \approx -3 - 4.124 \approx -7.124 \approx -1.78$$

$$x \approx 0.28$$

$$x \approx -1.78$$

6 Solve the following equations:

$$1. 3(x-1)^2 = x+24$$

$$2. 2x + 5y = 7$$

$$3x + 2y = 5$$

Answers:

$$1. 3(x-1)^2 = x+24$$

$$3(x-1)^2 = x+24 \Rightarrow 3x-32 = x+24$$

$$3x-32 = x+24 \Rightarrow 4(3x-3) = 2(x+2)$$

$$4(3x-3) = 2(x+2) \Rightarrow 12x-12 = 2(x+2) \quad 12x-12 = 2(x+2) \Rightarrow 12x-12 = 2x+4 \\ 12x-12 = 2x+4 \Rightarrow 12x-12-2x = 4 \quad 12x-2x = 4+12 \Rightarrow 10x = 4+12 \quad 10x = 16 \Rightarrow x = 85$$

$$2. 2x + 5y = 7$$

$$3x + 2y = 5$$

Eliminate one variable

Multiply the first equation by 3 and the second equation by 2 to align the coefficients of x

$$1. 3(2x+5y) = 3 \cdot 7 \Rightarrow 6x+15y = 21$$

$$2. 2(3x+2y) = 2 \cdot 5 \Rightarrow 6x+4y = 10$$

$$3. (6x+15y) - (6x+y) = 21-10 \Rightarrow 11y = 11$$

$$4. 11y = 11 \Rightarrow y = 1$$

$$5. y = 1$$

$$6. y = 1 \text{ in } 3x+2y=5$$

7. $3x+2(1)=5 \Rightarrow 3x+2=5$

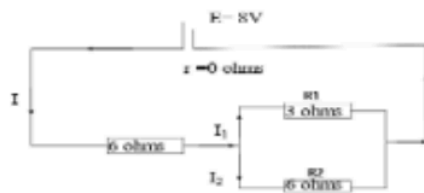
8. $3x+2=5-2 \Rightarrow 3x=3 \Rightarrow x=3 \Rightarrow x=1$

$X=1, Y=1$

7. For the following electrical circuit

Find:

- The total resistance of the circuit
- Current I_2 in the branched circuit.
- The power supplied by the cell.



Answers :

- The total resistance of the circuit

$E=8V$

$6\ \Omega$ in series with a parallel branch

Parallel resistors: $3\ \Omega$ and $6\ \Omega$

$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} \Rightarrow \frac{1}{R_p} = \frac{1}{3} + \frac{1}{6} \Rightarrow \frac{1}{R_p} = \frac{2}{6} + \frac{1}{6} = \frac{3}{6}$

$R_p = 2\ \Omega \Rightarrow R_T = R_s + R_p = 6 + 2 = 8\ \Omega$

Result $R_T = 8\ \Omega$

- Current I_2 in the branched circuit:

Ohm's law:

$$I = \frac{E}{RT} \quad E = 8\text{V and } RT = 8\Omega \quad I = \frac{8}{8} = 1\text{A} \quad V_{\text{parallel}} = I \cdot R_s = 1 \cdot 6 = 6\text{V}$$

Ohm's law for $R_2 = 6\Omega$

$$I_2 = \frac{V_{\text{parallel}}}{R_2} \quad I_2 = \frac{6}{6} = 1\text{A}$$

Result $I_2 = 1\text{A}$

c) The power supplied by the cell.

The total power P supplied by the cell is given by:

$$P = E \cdot I$$

Substituting $E = 8\text{V}$ and $I = 1\text{A}$

$$P = 8 \cdot 1 = 8\text{ W}$$

Result $P = 8\text{W}$

FINAL GRADE

75/100

GENERAL COMMENTS

Q1 BASE UNITS

[5MARKS]

All correct ,

(Cd) for Candela ideally

[5 Marks]

Q2 DERIVED UNITS

[5 MARKS]

All correct

[5 marks]

Q3 EQUILIBRIUM OF AN OBJECT ON AN INCLINED PLANE

[11 MARKS]

All correct

[11 marks]

Q4 SOLVING QUADRATIC EQUATIONS BY FACTORISING

[15 MARKS]

in 30 $x=-5$ but twice!, also $2x+1=0$ implies $x=-1/2$ not 12!!

[13 marks]

Q5 SOLUTION OF QUADRATIC EQUATIONS BY
FORMULA

[10 MARKS]

First part is good, second part is incorrect use of
formula.

[6 marks]

Q6 SIMULTANEOUS LINEAR EQUATIONS

[10 MARKS]

part 1 error in x multiplying and expansion of
brackets, part two all correct. [6
marks]

Q7 SIMPLE ELECTRICAL CIRCUIT

[9 MARKS]

Not well done some formulae used appropriately
but numerical calculations are incorrect

[3 marks]

total = 49 /65, 75%

However due to late submission, 1 week late with no
extenuating circumstances, mark is capped at 40%.

