STEM SCHOOLS · GRADE 10 · SEMESTER 1 · PHYSICS

Practice Midterm: PH 1.01 & PH 1.02

These are the questions most likely to come up, taken from your teachers' problem sets, the 2017 midterm and the official midterm guide, plus new questions in the same style. Tap an option to choose it. Use **Hint** if you're stuck. Press **Check my answers** when you finish. Step-by-step solutions are in the answer key at the end.

Part A · LO1 Measurement 32 multiple-choice	**Part B** · LO2 Newton's 3rd law 26 multiple-choice	**Part C** · Written answers 6 questions · show your steps	**Use** g = 9.8 m/s² unless the question says otherwise

PART A · PH 1.01 Measurement & Units

1 The active ingredient in a medicine is 400 mg. This is equivalent to...

(A) 4×10^{-3} g
(B) 4×10^{3} g
(C) 4×10^{-4} kg
(D) 4×10^{-6} kg

PH 1.01

2 A speed of 72 km/h is equivalent to...

(A) 10 m/s
(B) 20 m/s
(C) 1200 m/s
(D) 7200 m/s

PH 1.01

3 0.05 mm = ... km

(A) 5×10^{-5}
(B) 5×10^{8}
(C) 5×10^{-8}
(D) 5×10^{-7}

PH 1.01

4 In prefix form, 0.000001 m would be written as...

(A) 0.1 mm
(B) 0.01 mm
(C) 0.001 mm
(D) 0.0001 mm

PH 1.01

5 A football player who weighs 195 pounds kicks a ball over 40 yards at an initial speed of 34 miles per hour. These units belong to...

(A) The International System (SI)
(B) The French system (CGS)
(C) The German system
(D) The British system (FPS)

PH 1.01

6 Which of these is a basic (base) quantity in the SI system?

(A) Force
(B) Electric current
(C) Speed
(D) Volume

PH 1.01

7 The shortest unit of length of the following is...

(A) Decimetre
(B) Yard
(C) Foot
(D) Inch

PH 1.01

8 A syringe is labelled 6 mL. This is equivalent to...

(A) 6×10^{-3} cm³
(B) 6 cm³
(C) 6×10^{3} cm³
(D) 6×10^{-3} m³

PH 1.01

9 g/cm³ and kg/m³ are both units of density. Which statement is correct?

(A) g/cm³ is a smaller unit than kg/m³
(B) g/cm³ is a larger unit than kg/m³
(C) They are equal
(D) g/cm³ is the SI unit of density

PH 1.01

10 Car X: 90 km/h · Car Y: 240 m/min · Car Z: 15 m/s · Car T: 6 km/min. Which list is in ascending order of speed?

(A) Z < X < Y < T
(B) Y < Z < X < T
(C) Y < X < Z < T
(D) T < Y < X < Z

PH 1.01

11 Sarah wants to measure the diameter of an electric wire to an accuracy of 0.01 mm. Which tool should she use?

(A) A ruler
(B) A micrometer
(C) Vernier calipers
(D) A protractor

PH 1.01

12 A student's ammeter has a zero error. He measures a current several times. His measurements have...

(A) a random error
(B) a systematic error
(C) an unpredictable error
(D) no precision

PH 1.01

13 Which statement about systematic errors is true?

(A) They are the same (consistent) for every measurement

(B) They vary randomly

(C) They can be avoided by taking many readings

(D) They come only from parallax

PH 1.01

14 A student measured g four times: 10.52, 10.52, 10.53, 10.52 m/s². The true value is 9.8 m/s². Her results are...

(A) accurate, not precise

(B) precise, not accurate

(C) neither precise nor accurate

(D) both precise and accurate

PH 1.01

15 The real length of a garden is 250 m. An instrument shows 254 m. The relative error is...

(A) 0.016

(B) 0.04

(C) 0.08

(D) 0.16

PH 1.01

16 L is found by adding $L_1 = (5.2 \pm 0.1)$ cm and $L_2 = (5.8 \pm 0.2)$ cm. Then L =

(A) (11 ± 0.1) cm

(B) (11 ± 0.3) cm

(C) (11 ± 0.2) cm

(D) (11 ± 0.02) cm

PH 1.01

17 A rectangle measures $L = (6 \pm 0.1)$ m and $W = (5 \pm 0.2)$ m. Its area is...

(A) (30 ± 0.3) m²

(B) (30 ± 1.7) m²

(C) (30 ± 0.057) m²

(D) (30 ± 0.02) m²

PH 1.01

18 The error in measuring the radius of a sphere is 1%. The error in its volume is...

(A) 1%

(B) 2%

(C) 3%

(D) 4%

PH 1.01

19 The diameter of a circle is (40.0 ± 0.2) cm. The percentage error in its circumference is...

(A) 0.5%

(B) 1%

(C) 5%

(D) 10%

PH 1.01

20 Each side of a wooden cube is 10 cm with an uncertainty of ± 2 mm. The absolute uncertainty in its volume is...

(A) 0.06 cm^3 (B) 0.08 cm^3

(C) 60 cm^3 (D) 80 cm^3

PH 1.01

21 The percentage errors in mass and speed are 2% and 3%. The maximum error in kinetic energy (KE = ½mv^2) is...

(A) 11% (B) 8%

(C) 5% (D) 1%

PH 1.01

22 The diameter of a wire is d = (0.40 ± 0.005) mm. The percentage uncertainty in its cross-sectional area (A = πd^2/4) is...

(A) 2.50% (B) 1.56%

(C) 1.25% (D) 0.016%

PH 1.01

23 A boy of mass exactly 36.5 kg reads 38 kg on a faulty scale. His sister reads 14 kg on the same scale. Her actual mass is...

(A) 12.5 kg (B) 13.4 kg

(C) 14.6 kg (D) 15.5 kg

PH 1.01

24 The dimensional formula of force is...

(A) $M\,L\,T^{-1}$ (B) $M\,L\,T^{-2}$

(C) $M\,L^2\,T^{-2}$ (D) $M\,L^{-1}\,T^{-2}$

PH 1.01

25 Which relation has the dimensional formula $M\,L^2\,T^{-2}$?

(A) mass × acceleration (B) mass × velocity

(C) density × depth × free-fall acceleration (D) mass × height × free-fall acceleration

PH 1.01

26 A = B × C. The dimensions of A and B are $M\,L\,T^{-2}$ and L^2. The dimension of C is...

(A) $M\,L^3\,T^{-2}$ (B) $M\,L^2\,T^{-2}$

(C) $M\,L^{-3}\,T^{-2}$ (D) $M\,L^{-1}\,T^{-2}$

PH 1.01

27 For a short time, the speed of a car is $v = at^2 + bt^3$ (v in m/s, t in s). The units of a and b are...

(A) $m \cdot s^2$, $m \cdot s^4$

(B) m/s^2, m/s^3

(C) m/s^3, m/s^4

(D) m/s^4, m/s^5

PH 1.01

28 Newton's law of gravitation is $F = G\,M\,m\,/\,d^2$. The dimensions of G are...

(A) $M^2\,L^3\,T^{-2}$

(B) $M\,L^2\,T^{-2}$

(C) $M^{-1}\,L^3\,T^{-2}$

(D) $M\,L\,T^{-2}$

PH 1.01

29 The energy of a photon is $E = h\,f$ (h = Planck's constant, f = frequency). The dimensions of h are...

(A) $M\,L^2\,T^{-3}$

(B) $M\,L^2\,T^{-2}$

(C) $M\,L\,T^{-1}$

(D) $M\,L^2\,T^{-1}$

PH 1.01

30 The force on a current-carrying wire is $F = B\,I\,L$ (F in $kg \cdot m/s^2$, I in C/s, L in m). One tesla (unit of B) equals...

(A) $kg \cdot C^{-1} \cdot s^{-1}$

(B) $kg \cdot C \cdot s^{-1}$

(C) $kg \cdot C^{-1} \cdot s^{-2}$

(D) $kg \cdot m \cdot C^{-1} \cdot s^{-1}$

PH 1.01

31 $A = B^2\,C^{-1}$, where A has dimensions $M^2\,L^{-1}\,T^{-3}$ and C has $M^{-1}\,L^3\,T$. The dimension of B is...

(A) M^½ L T⁻¹

(B) M⁻¹ L⁻² T^½

(C) M L^½ T⁻²

(D) M⁻² L^-½ T

PH 1.01

32 Which of these can dimensional analysis NOT do?

(A) Check whether an equation is correct

(B) Find the dimensions of a constant

(C) Find the value of a pure number such as ½ in $KE = \frac{1}{2}mv^2$

(D) Help derive a relation between quantities

PH 1.01

PART B · PH 1.02 Forces & Newton's 3rd Law

33 A nail goes into a wooden block when the reaction of the block on the nail is...

(A) greater than the action of the hammer on the nail

(B) equal to the reaction of the nail on the hammer

(C) less than the action of the nail on the block

(D) less than the action of the hammer on the nail

PH 1.02

34 A kangaroo jumps forward because of Newton's 3rd law. The force it exerts on the ground is...

(A) smaller than the force of the ground on it

(B) greater than the force of the ground on it

(C) equal to the force of the ground on it

(D) nothing to do with the ground

PH 1.02

35 Earth is about 81 times heavier than the Moon. If Earth pulls the Moon with force F, the Moon pulls Earth with...

(A) zero

(B) F/81

(C) F/9

(D) F

PH 1.02

36 A helium balloon is held by a thread. The reaction to the force of gravity on the balloon is the force exerted by...

(A) the balloon on the thread

(B) the balloon on the Earth

(C) the thread on the balloon

(D) the thread on your hand

PH 1.02

37 A book rests on a table and pushes down on the table. The reaction to this force is...

(A) the force of Earth on the book

(B) the force of the table on the book

(C) the force of Earth on the table

(D) the force of the book on Earth

PH 1.02

38 A rifle recoils when fired. Compared with the bullet, the acceleration of the rifle is...

(A) smaller

(B) the same

(C) greater

(D) zero

PH 1.02

39 The action and reaction forces in Newton's 3rd law...

(A) always cancel each other out

(B) always act on different objects

(C) disappear once the object starts moving

(D) may be perpendicular to each other

PH 1.02

40 A man pushes a chair across the floor with 50 N. When does the chair push back on the man with 50 N?

(A) only if both are at rest
(B) only if both are accelerating
(C) only if both move at constant velocity
(D) in all of these cases

PH 1.02

41 In the last question, the chair moves at constant velocity. The friction force from the floor is...

(A) equal to 50 N
(B) greater than 50 N
(C) less than 50 N
(D) zero

PH 1.02

42 A spring scale is connected between two 10 N weights that hang over two pulleys, one on each side. The scale reads...

(A) 0 N
(B) 10 N
(C) 20 N
(D) another value

PH 1.02

43 A block slides at constant velocity on a horizontal surface. A 5 N force pulls it right, a 3 N force pulls it left, and friction is the only other horizontal force. Friction is...

(A) 2 N, leftward
(B) 2 N, rightward
(C) slightly less than 2 N, leftward
(D) slightly more than 2 N, leftward

PH 1.02

44 A 5 kg mass hangs at rest from a force C. The value of C is...

(A) 5 N
(B) 9.8 N
(C) 49 N
(D) 0 N

PH 1.02

45 A book rests on a table. Its weight W and the normal force N are equal and opposite, but they are NOT a 3rd-law pair because...

(A) they are not equal in size
(B) they act on the same object and are different types of force
(C) N is always larger than W
(D) W disappears when the book is still

PH 1.02

46 A ball has been thrown straight up and is still rising. Ignoring air resistance, the force(s) on it are...

(A) weight only
(B) weight and an upward force from the throw
(C) an upward force only
(D) no forces

PH 1.02

47 An aeroplane flies in a straight line at constant speed. Which is true?

(A) Thrust > drag and lift = weight

(B) Thrust = drag and lift > weight

(C) Thrust = drag and lift = weight

(D) Thrust > drag and lift > weight

PH 1.02

48 The least number of UNEQUAL forces that can keep an object in equilibrium is...

(A) 2

(B) 3

(C) 4

(D) 5

PH 1.02

49 A car moving at constant (uniform) velocity is an example of...

(A) static equilibrium

(B) dynamic equilibrium

(C) unbalanced forces

(D) non-equilibrium

PH 1.02

50 A 50 kg footballer kicks a 25 g ball with a force of 25 N east. Which is correct?

(A) The ball pushes the player with 50 N west

(B) The ball pushes the player with 50 N east

(C) The ball pushes the player with 25 N east

(D) The ball pushes the player with 25 N west

PH 1.02

51 The direction of the normal force is always...

(A) vertically upward

(B) perpendicular to the surface

(C) parallel to the surface

(D) in the direction of motion

PH 1.02

52 An object balances 12 kg on an equal-arm balance and reads 12 kg on a spring scale. On the Moon (g is 1/6 of Earth's), the balance and spring scale read...

(A) 12 kg, 12 kg

(B) 2 kg, 2 kg

(C) 12 kg, 2 kg

(D) 2 kg, 12 kg

PH 1.02

53 When you lean against a wall, the wall pushes horizontally on you. This force is a...

(A) normal force

(B) friction force

(C) applied force

(D) tension force

PH 1.02

54 Book A (weight 4 N) rests on book B (weight 6 N), which rests on a table. The net force on book B is...

(A) 10 N downward

(B) 4 N downward

(C) 6 N upward

(D) zero

PH 1.02

55 In the last question, the force of the table on book B is...

(A) 4 N

(B) 6 N

(C) 10 N

(D) 0 N

PH 1.02

56 A firefly hits the windscreen of a fast bus. Which is correct?

(A) The firefly feels a larger force

(B) The bus feels a larger force

(C) Both feel forces of the same size

(D) Both forces are in the same direction

PH 1.02

57 The horse pulls the cart and the cart pulls the horse back equally. How does the cart move?

(A) It can't, the forces cancel

(B) The horse pulls slightly harder

(C) The horse pulls before the cart can react

(D) The horse pushes the ground backward and the ground pushes the horse forward

PH 1.02

58 How does Newton's 3rd law explain a rocket taking off?

(A) The rocket pulls the Earth with a force equal to its weight

(B) The rocket pushes hot gases down, and the gases push the rocket up with an equal force

(C) The gases push with less force than the rocket's weight

(D) The rocket and gases have equal accelerations

PH 1.02

PART C · CONSTRUCTED RESPONSE Written answers

C1 Convert, showing your conversion factors: (a) 1.47 mile into inches (b) 60 mile/h into ft/s (c) 62.0 in into cm.

Write your steps here (or on paper)...

C2 Student 1 measures a pencil as 9.9 cm (real length 10 cm). Student 2 measures a classroom as 9.13 m (real length 9.11 m). Find the absolute and relative error for each. Whose measurement is more accurate? Why?

Write your steps here (or on paper)...

C3 A metal cube has side (2.00 ± 0.02) cm and mass (21.6 ± 0.2) g. (a) Find its density with the error. (b) Is this direct or indirect measurement? (c) Using ρ(aluminium) = 2.7 g/cm³, what is the metal likely to be?

Write your steps here (or on paper)...

C4 (a) Use dimensions to check whether $d = v_0t + \frac{1}{2}at^2$ is correct. (b) A student writes $KE = mv^2$. Is it dimensionally correct? Is it physically correct? What does this show about dimensional analysis?

Write your steps here (or on paper)...

C5 A 4 kg block is pulled across a rough floor by a horizontal 20 N force and moves at constant velocity. (a) Draw its free-body diagram. (b) Find its weight, the normal force and the friction force. (c) What kind of equilibrium is this?

Write your steps here (or on paper)...

C6 A book is at rest on a table. (a) Name every force acting on the book. (b) Identify the two Newton's 3rd-law pairs in the book–table–Earth system. (c) Explain why W and N on the book are not a 3rd-law pair, and why action and reaction never cancel.

Write your steps here (or on paper)...

ANSWER KEY

Step-by-step solutions

Try the paper first. Tap any question to open its solution.

Q1 → C 4 × 10⁻⁴ kg The active ingredient in a medicine is 400 mg. This is equivalent to...

1. 400 mg = 400 × 10^{-3} g = 0.4 g
2. 0.4 g = 0.4 × 10^{-3} kg = **4 × 10^{-4} kg**
3. Check A: 0.4 g ≠ 4 × 10^{-3} g, so A is wrong.

Q2 → B 20 m/s A speed of 72 km/h is equivalent to...

1. 72 × 1000 m ÷ 3600 s
2. = 72 ÷ 3.6 = **20 m/s**

Q3 → C 5 × 10⁻⁸ 0.05 mm = ... km

1. 0.05 mm = 5 × 10^{-2} × 10^{-3} m = 5 × 10^{-5} m
2. 5 × 10^{-5} m × (1 km / 10^{3} m) = **5 × 10^{-8} km**

Q4 → C 0.001 mm In prefix form, 0.000001 m would be written as...

1. 0.000001 m = 10^{-6} m
2. 10^{-6} × 10^{3} mm = 10^{-3} mm = **0.001 mm** (= 1 μm)

Q5 → D The British system (FPS) A football player who weighs 195 pounds kicks a ball over 40 yards at an initial speed of 34 miles per hour. These units belong to...

1. Pound, yard and mile are units of the **British (foot–pound–second) system**.

Q6 → B Electric current Which of these is a basic (base) quantity in the SI system?

1. Force (N), speed (m/s) and volume (m^3) are derived.
2. Electric current (ampere, A) is one of the 7 base quantities → **B**.

Q7 → D Inch The shortest unit of length of the following is...

1. 1 dm = 10 cm · 1 yd = 91.44 cm · 1 ft = 30.48 cm · 1 in = 2.54 cm
2. Shortest = **inch**

Q8 → B 6 cm³ A syringe is labelled 6 mL. This is equivalent to...

1. 1 mL = 10^{-3} L and 1 L = 10^{3} cm^3
2. 6 mL = 6 × 10^{-3} × 10^{3} cm^3 = **6 cm^3**

Q9 → B g/cm³ is a larger unit than kg/m³ g/cm³ and kg/m³ are both units of density. Which statement is correct?

1. 1 g = 10^{-3} kg and 1 cm³ = 10^{-6} m³
2. 1 g/cm³ = 10^{-3} / 10^{-6} = 10^{3} kg/m³
3. So 1 g/cm³ = 1000 kg/m³ → g/cm³ is **larger**. The SI unit is kg/m³.

Q10 → B Y < Z < X < T Car X: 90 km/h · Car Y: 240 m/min · Car Z: 15 m/s · Car T: 6 km/min. Which list is in ascending order of speed?

1. X = 90 ÷ 3.6 = 25 m/s
2. Y = 240 m ÷ 60 s = 4 m/s
3. Z = 15 m/s · T = 6000 m ÷ 60 s = 100 m/s
4. Ascending: **Y (4) < Z (15) < X (25) < T (100)**

Q11 → B A micrometer Sarah wants to measure the diameter of an electric wire to an accuracy of 0.01 mm. Which tool should she use?

1. Ruler reads to 1 mm; Vernier to about 0.1 mm.
2. The **micrometer screw gauge** reads to 0.01 mm.

Q12 → B a systematic error A student's ammeter has a zero error. He measures a current several times. His measurements have...

1. A zero error shifts every reading by the same amount in the same direction.
2. That is a **systematic error**. Repeating the readings won't remove it.

Q13 → A They are the same (consistent) for every measurement Which statement about systematic errors is true?

1. Systematic errors repeat the same way each time → **A**.
2. Averaging many readings reduces *random* errors, not systematic ones.

Q14 → B precise, not accurate A student measured g four times: 10.52, 10.52, 10.53, 10.52 m/s². The true value is 9.8 m/s². Her results are...

1. The readings agree closely with each other → **precise**.
2. They are far from 9.8 → **not accurate**.

Q15 → A 0.016 The real length of a garden is 250 m. An instrument shows 254 m. The relative error is...

1. Δx = |250 − 254| = 4 m
2. r = 4 / 250 = **0.016** (1.6%)

Q16 → B (11 ± 0.3) cm L is found by adding L_1 = (5.2 ± 0.1) cm and L_2 = (5.8 ± 0.2) cm. Then L =

1. L_0 = 5.2 + 5.8 = 11 cm
2. ΔL = 0.1 + 0.2 = 0.3 cm
3. L = **(11 ± 0.3) cm**

Q17 → B (30 ± 1.7) m² A rectangle measures L = (6 ± 0.1) m and W = (5 ± 0.2) m. Its area is...

1. $r_1 = 0.1/6 = 0.017$ · $r_2 = 0.2/5 = 0.04$
2. $r = 0.017 + 0.04 = 0.057$
3. $A_0 = 6 \times 5 = 30\ m^2$ · $\Delta A = 0.057 \times 30 \approx 1.7\ m^2$
4. A = **(30 ± 1.7) m²**. (C gives r, not ΔA.)

Q18 → C 3% The error in measuring the radius of a sphere is 1%. The error in its volume is...

1. $V \propto r^3$, and 4/3 π has no error
2. r_V = 3 × 1% = **3%**

Q19 → A 0.5% The diameter of a circle is (40.0 ± 0.2) cm. The percentage error in its circumference is...

1. r_C = r_d = 0.2 / 40.0
2. = 0.005 = **0.5%**

Q20 → C 60 cm³ Each side of a wooden cube is 10 cm with an uncertainty of ± 2 mm. The absolute uncertainty in its volume is...

1. 2 mm = 0.2 cm → r_L = 0.2/10 = 0.02
2. r_V = 3 × 0.02 = 0.06
3. $V_0 = 10^3 = 1000\ cm^3$
4. $\Delta V = 0.06 \times 1000 =$ **60 cm³**

Q21 → B 8% The percentage errors in mass and speed are 2% and 3%. The maximum error in kinetic energy (KE = ½mv²) is...

1. r_KE = r_m + 2 r_v (½ has no error)
2. = 2% + 2 × 3% = **8%**

Q22 → A 2.50% The diameter of a wire is d = (0.40 ± 0.005) mm. The percentage uncertainty in its cross-sectional area (A = πd²/4) is...

1. r_d = 0.005 / 0.40 = 0.0125 = 1.25%
2. r_A = 2 × 1.25% = **2.50%**

Q23 → A 12.5 kg A boy of mass exactly 36.5 kg reads 38 kg on a faulty scale. His sister reads 14 kg on the same scale. Her actual mass is...

1. Error = 38 − 36.5 = +1.5 kg (reads too high)
2. Sister's real mass = 14 − 1.5 = **12.5 kg**

Q24 → B M L T⁻² The dimensional formula of force is...

1. $[m] = M$ · $[a] = L\ T^{-2}$
2. [F] = **M L T⁻²**

Q25 → D mass × height × free-fall acceleration Which relation has the dimensional formula $M L^2 T^{-2}$?

1. A: $M L T^{-2} \cdot$ B: $M L T^{-1}$
2. C: $M L^{-3} \cdot L \cdot L T^{-2} = M L^{-1} T^{-2}$ (pressure)
3. D: $M \cdot L \cdot L T^{-2} =$ **$M L^2 T^{-2}$** (potential energy mgh)

Q26 → D $M L^{-1} T^{-2}$ A = B × C. The dimensions of A and B are $M L T^{-2}$ and L^2. The dimension of C is...

1. $[C] = M L T^{-2} \div L^2$
2. = **$M L^{-1} T^{-2}$**

Q27 → C m/s^3, m/s^4 For a short time, the speed of a car is $v = at^2 + bt^3$ (v in m/s, t in s). The units of a and b are...

1. $at^2 = m/s \rightarrow a = (m/s) \div s^2 = m/s^3$
2. $bt^3 = m/s \rightarrow b = (m/s) \div s^3 = m/s^4$
3. Answer: **m/s^3 and m/s^4**

Q28 → C $M^{-1} L^3 T^{-2}$ Newton's law of gravitation is $F = G M m / d^2$. The dimensions of G are...

1. $[G] = M L T^{-2} \times L^2 \div M^2$
2. = **$M^{-1} L^3 T^{-2}$**

Q29 → D $M L^2 T^{-1}$ The energy of a photon is E = h f (h = Planck's constant, f = frequency). The dimensions of h are...

1. $[E] = M L^2 T^{-2} \cdot [f] = T^{-1}$
2. $[h] = M L^2 T^{-2} \times T =$ **$M L^2 T^{-1}$**

Q30 → A $kg \cdot C^{-1} \cdot s^{-1}$ The force on a current-carrying wire is F = B I L (F in kg·m/s², I in C/s, L in m). One tesla (unit of B) equals...

1. $B = kg \cdot m \cdot s^{-2} \div (C \cdot s^{-1} \times m)$
2. $= kg \cdot s^{-2} \cdot s \cdot C^{-1} =$ **$kg \cdot C^{-1} \cdot s^{-1}$**

Q31 → A M^½ L T^{-1} $A = B^2 C^{-1}$, where A has dimensions $M^2 L^{-1} T^{-3}$ and C has $M^{-1} L^3 T$. The dimension of B is...

1. $B^2 = A \times C = M^2 L^{-1} T^{-3} \times M^{-1} L^3 T = M L^2 T^{-2}$
2. $B = (M L^2 T^{-2})^{\wedge}½ =$ **M^½ L T^{-1}**

Q32 → C Find the value of a pure number such as ½ in KE = ½mv² Which of these can dimensional analysis NOT do?

1. Pure numbers are dimensionless, so dimensions cannot reveal them.
2. A dimensionally correct equation can still be physically wrong → **C**.

Q33 → D less than the action of the hammer on the nail A nail goes into a wooden block when the reaction of the block on the nail is...

1. Two forces act on the nail: hammer pushes it in, block pushes it back.
2. They act on the same object, so they can differ. The nail moves in when the block's push is **less than the hammer's push**.

Q34 → C equal to the force of the ground on it A kangaroo jumps forward because of Newton's 3rd law. The force it exerts on the ground is...

1. These two forces are an action–reaction pair, so they are **equal** and opposite.

Q35 → D F Earth is about 81 times heavier than the Moon. If Earth pulls the Moon with force F, the Moon pulls Earth with...

1. Earth on Moon and Moon on Earth are a 3rd-law pair.
2. They are equal: **F**. Mass only changes each body's acceleration.

Q36 → B the balloon on the Earth A helium balloon is held by a thread. The reaction to the force of gravity on the balloon is the force exerted by...

1. Action: Earth pulls balloon (gravity).
2. Reaction: **balloon pulls Earth**, also gravity, opposite direction.

Q37 → B the force of the table on the book A book rests on a table and pushes down on the table. The reaction to this force is...

1. Action: book pushes table (contact force).
2. Reaction: **table pushes book** up. Both are contact forces on different objects.

Q38 → A smaller A rifle recoils when fired. Compared with the bullet, the acceleration of the rifle is...

1. Rifle on bullet = bullet on rifle (equal forces).
2. The rifle's mass is much bigger, so a = F/m is **smaller**.

Q39 → B always act on different objects The action and reaction forces in Newton's 3rd law...

1. A pair always acts on **two different objects**, so the forces never cancel.
2. They are always opposite (never perpendicular) and exist whether moving or not.

Q40 → D in all of these cases A man pushes a chair across the floor with 50 N. When does the chair push back on the man with 50 N?

1. Newton's 3rd law is true **in all cases**: rest, constant velocity, or accelerating.

Q41 → A equal to 50 N In the last question, the chair moves at constant velocity. The friction force from the floor is...

1. Constant velocity → dynamic equilibrium → $\Sigma F = 0$
2. $50\ N - f = 0 \rightarrow f =$ **50 N**

Q42 → B 10 N A spring scale is connected between two 10 N weights that hang over two pulleys, one on each side. The scale reads...

1. The scale reads the tension in the string, and the tension is 10 N.
2. One weight pulls; the other plays the role of a wall holding the scale. Reading = **10 N**.

Q43 → A 2 N, leftward A block slides at constant velocity on a horizontal surface. A 5 N force pulls it right, a 3 N force pulls it left, and friction is the only other horizontal force. Friction is...

1. Take right as +: 5 − 3 − f = 0
2. f = **2 N, leftward** (exactly, not slightly more)

Q44 → C 49 N A 5 kg mass hangs at rest from a force C. The value of C is...

1. C = mg = 5 × 9.8 = **49 N**, upward

Q45 → B they act on the same object and are different types of force A book rests on a table. Its weight W and the normal force N are equal and opposite, but they are NOT a 3rd-law pair because...

1. Both W and N act **on the book**, and W is gravity while N is a contact force.
2. A 3rd-law pair must act on different objects and be the same type.

Q46 → A weight only A ball has been thrown straight up and is still rising. Ignoring air resistance, the force(s) on it are...

1. Nothing touches the ball, so only gravity acts: **weight only**.
2. The 'force of the throw' stopped when the hand let go.

Q47 → C Thrust = drag and lift = weight An aeroplane flies in a straight line at constant speed. Which is true?

1. Dynamic equilibrium → ΣF = 0 in both directions.
2. Horizontal: **thrust = drag**. Vertical: **lift = weight**.

Q48 → B 3 The least number of UNEQUAL forces that can keep an object in equilibrium is...

1. Two forces balance only if they are equal and opposite.
2. With unequal forces you need at least **3** (for example, 3 N, 4 N and 5 N at angles).

Q49 → B dynamic equilibrium A car moving at constant (uniform) velocity is an example of...

1. Net force zero and moving at constant velocity → **dynamic equilibrium**.
2. Engine force forward = friction backward.

Q50 → D The ball pushes the player with 25 N west A 50 kg footballer kicks a 25 g ball with a force of 25 N east. Which is correct?

1. Player on ball = 25 N east
2. Ball on player = **25 N west**

Q51 → B perpendicular to the surface The direction of the normal force is always...

1. The normal force is **perpendicular to the contact surface**. On a slope it is not vertical.

Q52 → C 12 kg, 2 kg An object balances 12 kg on an equal-arm balance and reads 12 kg on a spring scale. On the Moon (g is 1/6 of Earth's), the balance and spring scale read...

1. The balance compares masses; both sides change with g → still **12 kg**.
2. The spring scale measures weight, which drops to 1/6 → **2 kg**.

Q53 → A normal force When you lean against a wall, the wall pushes horizontally on you. This force is a...

1. A surface pushing perpendicular to itself = **normal force**, even when horizontal.

Q54 → D zero Book A (weight 4 N) rests on book B (weight 6 N), which rests on a table. The net force on book B is...

1. B is at rest → static equilibrium → net force = **zero**.
2. Down: 6 N + 4 N. Up: table pushes 10 N.

Q55 → C 10 N In the last question, the force of the table on book B is...

1. Table on B = weight of B + push of A on B = 6 + 4 = **10 N** upward.

Q56 → C Both feel forces of the same size A firefly hits the windscreen of a fast bus. Which is correct?

1. They form a 3rd-law pair → **same size**, opposite directions.
2. The firefly's tiny mass gives it a huge acceleration.

Q57 → D The horse pushes the ground backward and the ground pushes the horse forward The horse pulls the cart and the cart pulls the horse back equally. How does the cart move?

1. Horse–cart forces act on different objects and never cancel, but they are internal to the system.
2. The **ground** pushes the horse forward (reaction to the hooves pushing back). That outside force moves the system.

Q58 → B The rocket pushes hot gases down, and the gases push the rocket up with an equal force How does Newton's 3rd law explain a rocket taking off?

1. Action: rocket pushes exhaust gases downward.
2. Reaction: **gases push the rocket upward** with an equal force.

C1 Convert, showing your conversion factors: (a) 1.47 mile into inches (b) 60 mile/h into ft/s (c) 62.0 in into cm.

1. (a) 1.47 mi × (5280 ft / 1 mi) × (12 in / 1 ft) = 93 139 in ≈ **9.31×10^4 in**
2. (b) 60 mi/h × (5280 ft / 1 mi) × (1 h / 3600 s) = **88 ft/s**
3. (c) 62.0 in × (2.54 cm / 1 in) = 157.48 ≈ **157.5 cm**

C2 Student 1 measures a pencil as 9.9 cm (real length 10 cm). Student 2 measures a classroom as 9.13 m (real length 9.11 m). Find the absolute and relative error for each. Whose measurement is more accurate? Why?

1. Student 1: $\Delta x = |10 - 9.9| = 0.1$ cm · $r = 0.1/10 = 0.01 = 1\%$
2. Student 2: $\Delta x = |9.11 - 9.13| = 0.02$ m $= 2$ cm · $r = 0.02/9.11 = 0.0022 = 0.22\%$
3. **Student 2 is more accurate**: smaller relative error, even though the absolute error is bigger.
4. Results: pencil = (10 ± 0.1) cm · class = (9.11 ± 0.02) m

C3 A metal cube has side (2.00 ± 0.02) cm and mass (21.6 ± 0.2) g. (a) Find its density with the error. (b) Is this direct or indirect measurement? (c) Using ρ(aluminium) = 2.7 g/cm³, what is the metal likely to be?

1. $V_0 = 2.00^3 = 8.00$ cm³ · $r_V = 3 \times (0.02/2.00) = 0.03$
2. $r_m = 0.2/21.6 = 0.0093$
3. Density = m ÷ V → $r_\rho = r_m + r_V = 0.0093 + 0.03 = 0.039$
4. $\rho_0 = 21.6 / 8.00 = 2.70$ g/cm³ · $\Delta\rho = 0.039 \times 2.70 \approx 0.11$ g/cm³
5. (a) **ρ = (2.70 ± 0.11) g/cm³**
6. (b) **Indirect**: two measurements (mass and length) combined by a formula.
7. (c) Matches **aluminium**.

C4 (a) Use dimensions to check whether $d = v_0t + \frac{1}{2}at^2$ is correct. (b) A student writes $KE = mv^2$. Is it dimensionally correct? Is it physically correct? What does this show about dimensional analysis?

1. (a) $[d] = L \cdot [v_0t] = LT^{-1} \times T = L \cdot [\frac{1}{2}at^2] = LT^{-2} \times T^2 = L$. All terms are L → **dimensionally correct**.
2. (b) $[mv^2] = M(LT^{-1})^2 = ML^2T^{-2}$ = dimension of energy → dimensionally correct.
3. But the real formula is $KE = \frac{1}{2}mv^2$, so it is **physically wrong**.
4. Conclusion: dimensional analysis can't find pure numbers like ½. A dimensionally correct equation isn't always physically correct.

C5 A 4 kg block is pulled across a rough floor by a horizontal 20 N force and moves at constant velocity. (a) Draw its free-body diagram. (b) Find its weight, the normal force and the friction force. (c) What kind of equilibrium is this?

1. (a) Four arrows from the block: W down, N up, 20 N applied forward, friction f backward. Equal pairs drawn with equal lengths.
2. (b) $W = mg = 4 \times 9.8 =$ **39.2 N** down
3. Vertical $\Sigma F = 0$ → $N = W =$ **39.2 N** up
4. Horizontal $\Sigma F = 0$ (constant velocity) → $f =$ **20 N** backward
5. (c) **Dynamic equilibrium**: net force zero while moving at constant velocity.

C6 A book is at rest on a table. (a) Name every force acting on the book. (b) Identify the two Newton's 3rd-law pairs in the book–table–Earth system. (c) Explain why W and N on the book are not a 3rd-law pair, and why action and reaction never cancel.

1. (a) Weight W (Earth on book, down) and normal force N (table on book, up).
2. (b) Pair 1: Earth pulls book down ↔ book pulls Earth up (gravity). Pair 2: book pushes table down ↔ table pushes book up (contact).
3. (c) W and N both act on the **same object** and are **different types**. They are equal only because the book is in equilibrium.
4. Action and reaction act on **different objects**, so they can't cancel; forces only cancel when they act on the same object.
