3. (a) $F = m_{total} a$

    → +ve: $50 = (20 + 5 + 10)a$

    $a = \dfrac{50}{35} = 1.43$ m/s^2

    (b) Let force on cube C by cube B be F_B

    → +ve: $F_B = m_c a_c$ (from (a), $a_c = 1.43$ m/s^2)

    ∴ $F_B = 10 \times 1.43 = 14.3$ N

4. (a) Consider cube A. (∵ strings taut ∴ acceleration of all 3 cubes are the same.)

    $F_T = m_A a_A$

    $5 = 5a_A$, ($F_T = 5$ N, tension in string pulling A.)

    $a_A = 1.0$ m/s^2 ∴ acceleration of cubes = 1.0 m/s^2

    (b) $F = (m_A + m_B + m_C)a$

    $= (5 + 5 + 5)(1.0)$

    $= 15.0$ N

    Consider B:

    → +ve: $T - 5 = m_B a_B$

    $T = 5 + 5(1.0) = 10.0$ N

5. → +ve: $F = ma$

    $12 - f = 5 \times 2.00$

    $f = 12 - 10$

    $= 2.0$ N

6. (a)
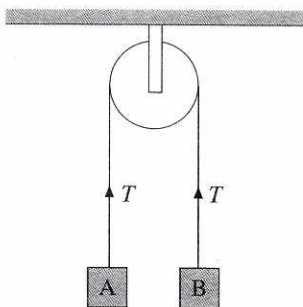
Take $g = 10$ m/s^2

For Block A:

↓

+ve $mg - T = ma$

$10m - T = 3m$

$T = 7m$ .... (1)

For Block B:

+ve $T - 5g = 5a$

↑ $T = 5(10) + 5(3)$

$= 65$ N
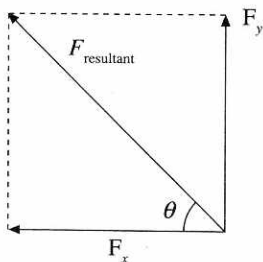
    (b) Sub $T = 65$ N into (1):

    $m = \dfrac{65}{7} = 9.29$ kg.

7. **Method 1:**
Use a scale diagram and measure the length of $F_{resultant}$.

Method 2:

+ve: $F_y = 10 - 3 = 7$ N
↑

← +ve: $F_x = 7$ N

$F_{resultant} = \sqrt{F_x^2 + F_y^2}$
$= \sqrt{49 + 49}$
$= \sqrt{98}$
$= 9.90$ N

$\tan \theta = \dfrac{F_y}{F_x}$ $\therefore$ $\theta = 45°$

$F = ma$ $\therefore$ $a = \dfrac{9.90}{2} = 4.95$ m/s^2

at an angle of 45° to the $-$ve x-axis

(c) $\dfrac{v - 0}{3.0} = g = 10$

$v = 30$ m/s

Distance travelled:

Method 1:

$s = ut + \dfrac{1}{2}at^2$

$= 0 + \dfrac{1}{2}(10)(3)^2 = 45$ m

Method 2:

Area under graph $= \dfrac{1}{2}(30)(3.0)$

$= 45$ m

3. **(a)** It is the gravitational force per unit mass.

(b) mass of rock $= \dfrac{\text{weight on Earth}}{g_{earth}}$

$= \dfrac{240}{10}$

$= 24$ kg

weight of rock on Moon = mass of rock $\times g_{moon}$
$= 24 \times 1.6$
$= 38.4$ N

• TOPIC **4** •

Mass, Weight and Density

Multiple Choice Questions:

1.	B		**2.**	B		**3.**	D	
4.	A		**5.**	D		**6.**	C	
7.	D		**8.**	D		**9.**	A	
10.	B		**11.**	C				

Structured Questions:

1. **(a)** Mass of an object is the amount of matter in an object and it is a fixed quantity.
The weight of an object is the force exerted on the mass of an object by a gravitational field when the object is placed in the gravitational field. The weight can vary depending on the location of the object (i.e. on the Moon versus on Earth).

(b) The mass of a body is a measure of the inertia of the body, which is a tendency of the body to resist change from its present state of rest or uniform velocity along a straight line. The larger the mass of a body, the larger the resultant force required to change its state of motion.

2. **(a)** The *mass* of a body is the amount of matter in a body.

(b) **(i)** 0 N

     (ii) $mg = 0.5 \times 10 = 5$ N

• TOPIC **5** •

Turning Effect of Forces

Multiple Choice Questions:

1.	C	**2.**	D	**3.**	B
4.	D				
5.	B				

Comments:
(A) is out because it sits in the plane of the rim of the bowl. (D) is out because it is at the baseline. (C) is out because it is the midpoint of the base of the bowl; obviously more of the bowl is above this point than below it.

6.	C	**7.**	D	**8.**	C
9.	D				
10.	B				

Comments:
For option B, taking moments about the point where force 1.0 N acts,
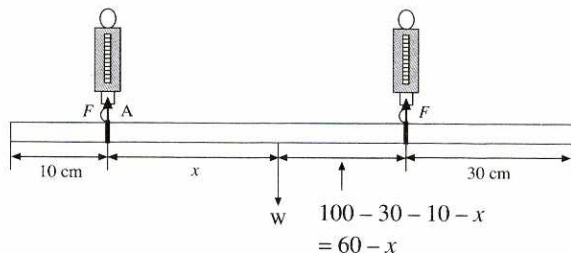
↻ moment: $3.0 \times x = 3.0x$

↺ moment: $4.0 \times 4x = 16.0x$

Since ↻ moment $\neq$ ↺ moment, disc is not in equilibrium.
Note: The upward forces (3.0 N + 1.0 N) balance the downward force (4.0 N), hence the resultant force is 0 N.

Structured Questions:

1.

$$w \quad 100 - 30 - 10 - x$$
$$= 60 - x$$

Let force by each spring balance be F.
Resolve forces on rod:

+ve $\qquad F + F - W = 0$

↑ $\qquad 2F = W = 5 \ g$

$\qquad 2F = 50$

$\qquad F = 25 \ N$

Take moment about point A :

A: $\qquad x \times W - 60 \times F = 0$

$\qquad x \times 50 - 60 \times 25 = 0$

$\qquad x = 30 \ cm$

$10 + x = 10 + 30$

$\qquad = 40 \ cm$

∴ Position of centre of mass of rod is 40 cm from the left.

2. Conditions for stability:
1. Lower the c.g.
2. Increase the base area.

To prevent his opponent from knocking him down or out of the ring, the wrestler must make sure he has a very stable position.

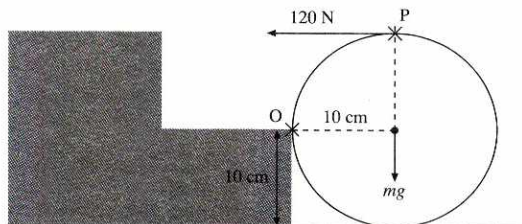1. Lowering of centre-of-gravity:
   The wrestler is "bottom-heavy" (lower half of the body is heavier).
   He further lowers his centre of gravity by squatting as low as possible.
2. Increasing the base area.
   The wrestler squats with his legs wide apart to increase the base area of his body.

3.

Take moments about point O:

O: $\qquad mg \times 10 - 120 \times 10 = 0$

$\qquad mg = 120$

$\qquad m = \dfrac{120}{10} = 12 \ kg$
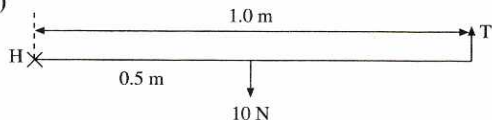
4. **(a)** mass of helium = density × volume

$$= 0.164 \times \left(\frac{10}{100} \right)^3$$

$$= 1.64 \times 10^{-4} \ kg$$

weight of helium = $mg = 1.64 \times 10^{-4} \times 10$

$$= 1.64 \times 10^{-3} \ N$$

(b)

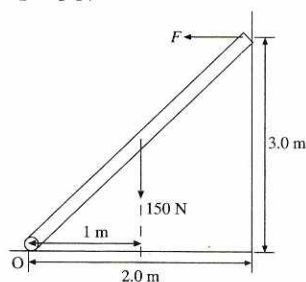Take moments about H:

H: $\qquad 0.5 \times 10 - 1.0 \times T = 0$

$\qquad T = 5 \ N$

5.

Take moments about O:

O: $\qquad 1.0 \times 150 - 3.0 \times F = 0$

$$F = \frac{150}{3.0}$$
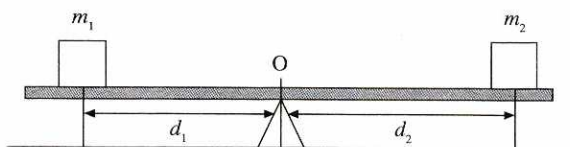
$$= 50 \ N$$

6. Equipment: 1. Uniform metre rule
2. Pivot
3. Different masses (brass weights)

Setup:

1. The uniform metre rule is pivoted at its midpoint O (centre of mass).
2. m_1 and m_2 are two different masses which are placed on the metre rule and their distances, d_1 and d_2 from the midpoint O are adjusted until the metre-rule is horizontal.
3. The moment of each of these masses is calculated using: $\tau = mg \times d$.
4. It will be shown that $\tau_1 = \tau_2$
   ∴ $m_1 g d_1 = m_2 g d_2$
   ∴ $m_1 d_1 = m_2 d_2$
5. Steps 1 to 4 can be repeated for different sets of values of m_1 and m_2, with d_1 and d_2.

• TOPIC 6 •

Pressure

Multiple Choice Questions:

1.	D	2.	B	3.	D	
4.	C	5.	B	6.	A	
7.	A	8.	C	9.	A	
10.	C					

Solutions:

$h_{water}\rho_{water}g = h_{kerosene}\rho_{kerosene}g$

$5.0 \times \rho_{water} = h \times \rho_{kerosene}$

$h = 5.0 \times \dfrac{\rho_{water}}{\rho_{kerosene}} = 5.0\left(\dfrac{1000}{810}\right)$

$= 6.17$ cm

11. D

Structured Questions:

1. (a) $P = \dfrac{F}{A}$

P: Pressure, F: Force, A: Area

(b) maximum pressure $= \dfrac{\text{weight}}{\text{smallest base area}}$

$= \dfrac{280}{0.2 \times 0.4}$

$= 3500$ N/m^2

2. (a) X: $h_x = 150 - 44 - 30 = 76$ cm

$\therefore\ P_X = \rho_X \times 10 \times 0.76$ Pa $= 7.6\rho_X$ Pa

Y: $h_y = 150 - 52 - 30 = 68$ cm

$\therefore\ P_Y = \rho_Y \times 10 \times 0.68$ Pa $= 6.8\rho_Y$ Pa

(b) $P_X = \rho g h = 13594 \times 10 \times 0.76$

$= 1.03 \times 10^5$ Pa

(c) Y contains mercury but the space above the liquid column is not vacuum and contains air.

Comments:

Y cannot contain a liquid that is of a higher density than X, since mercury has the highest density of all known liquids at room temperature.

3. (a) $\dfrac{F}{10} = \dfrac{500 \times 10}{A}$

$\dfrac{100}{10} = \dfrac{500 \times 10}{A}$

$A = 500$ cm^2

(b) Volume of liquid $= 500 \times 9 = 4500$ cm^3

$\therefore$ Let d be the distance smaller piston is pushed down.

$10 \times d = 4500$

$d = 450$ cm

$= 4.50$ m

(c) Gas is compressible whereas oil, being a liquid, is incompressible.

4. (a) $\Delta h = 77 - 69 = 8$ cm $= 0.08$ m

$\Delta P = \rho g \Delta h$

$= 13594 \times 10 \times 0.08 = 10875.2$ Pa

$= 1.09 \times 10^4$ Pa

(b) $\Delta P = h \times 1.15 \times 10$

$h = \dfrac{10\,875.2}{1.15 \times 10}$

$= 945.6$ m

$= 946$ m

5. (a) A: water
B: kerosene

(b)
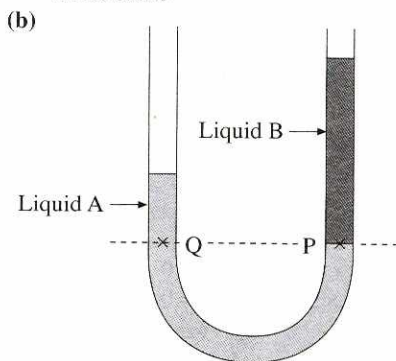
(c) Along PQ: pressure of water = pressure of kerosene.

$P_{atm} + P_A = P_{atm} + P_B$

$(h_1 - 2.3)\,\rho_w g = (h_2 - 2.3)\rho_k g$

$h_1 = \dfrac{\rho_k}{\rho_w}(h_2 - 2.3) + 2.3$

$h_1 = 0.81\, h_2 + 0.437$

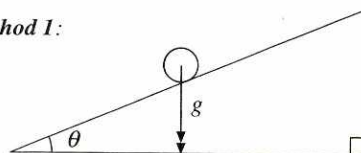## • TOPIC 7 •

Energy, Work and Power

Multiple Choice Questions:

1. A 2. B

3. A

Method 1:

As the particle slides up the plane, the height h increases.

height $h = s \sin \theta$, s is distance along plane

As $h \uparrow$, GPE also $\uparrow$

Since plane is smooth, by principle of conservation of energy;

Going up plane, Loss of KE = Gain in $GPE = mgh$

$GPE \propto + h\ \therefore\ GPE \propto s \sin \theta\ \therefore\ GPE \propto s$

Hence, $KE \propto - s$ (Loss, therefore $-$ve sign).