4.5. Simplification of a force and couple system

The given force (F) and couple (C) can be simplified to a force and couple at a new point. The new point is chosen to simplify the system. The moment (M) and force (F) Acting on the new point A can be resolved into components:

$$ F_A = \sum F = 0 $$

$$ M_A = \sum M = 0 $$

By resolving the force at point A, we get:

$$ F_A = (F_A, 0) $$

$$ M_A = (M_A, 0) $$

Where:

- $$ F_A $$ is the force at point A.
- $$ M_A $$ is the moment at point A.

The system can be simplified by considering the free force (free force) and the sliding force (sliding force) acting on the system. The free force is the force that moves the system as a whole, while the sliding force is the force that causes the system to slide along a specified surface.
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\[ \sum F_x = 0 \]

\[ \sum F_y = 0 \]

\[ \sum M = 0 \]

\[ \text{القوة} \ F \] في نقطة (A)

\[ \text{القوة} \ F \] في نقطة (B)

\[ M = Fd \]

\[ \text{نتيجة القوى} \ (\text{Resultant}) \]

\[ \text{المستقيمات} \ (\text{Couples}) \]

\[ W_R = W_1 + W_2 \]

\[ (M_a)_0 = W_1d_1 + W_2d_2 \]

\( \text{أعمال مثالية} \) 

\( \text{(Same external effect)} \)
Ex. Determine the resultant couple moment acting on the beam.

**Solution:**

**Method (1): Moments:**

\[ M_{A} = -400 \times 3 + 400 \times 5 = 200 \times 0.2 - 300 \times 5 \]
\[ M_{A} = -740 \text{ N.m} \quad \text{or} \quad 740 \text{ N.m} \]

**Method (2): Couples:**

Couple (1): \( M_{1} = (400 \times 2) = 800 \text{ N.m} \quad \text{or} \quad 800 \text{ N.m} \)

Couple (2): \( M_{2} = (200 \times 0.2) = 40 \text{ N.m} \quad \text{or} \quad 40 \text{ N.m} \)

Couple (3): \( M_{3} = (300 \times 5) = 1500 \text{ N.m} \quad \text{or} \quad 1500 \text{ N.m} \)

\[ \sum M_{F} = 800 - 40 - 1500 = -740 \text{ N.m} \]
\[ \text{or} = 740 \text{ N.m} \]

Ex. Determine the magnitude of \( F \) so that the resultant couple moment acting on the beam is \( 1.5 \text{ kN.m} \) clockwise.

**Solution:**

\[ \sum M_{F} = 1.5 \text{ kN.m} + (2 \text{ kN} \times 0.3) - (F \times 0.9) \]
\[ \Rightarrow F = 2.33 \text{ kN} \quad \text{or} \quad 2.33 \text{ kN} \quad \text{up} \]