

COUPLE

"Two equal opposite and parallel forces, whose line of action are different, form a couple."

ARM, Moment and DIRECTION of A COUPLE:-

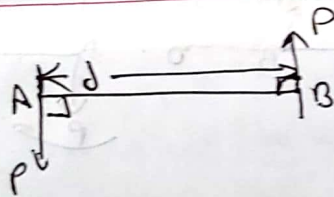
i) Arm of a couple:-

The \perp distance (d) between the line of action of the two equal, opposite and parallel forces, is known as "Arm of a couple".

ii) Moment of a couple:-

The moment of a couple is the product of the forces and the arm of the couple.

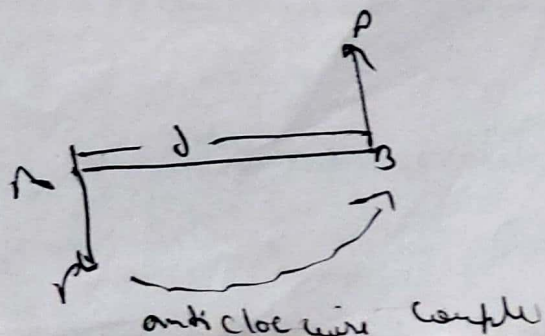
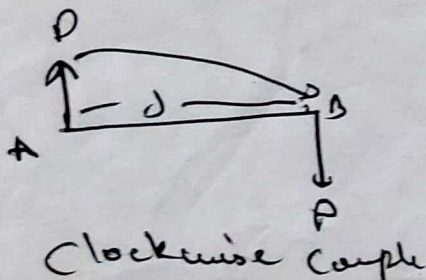
$$\text{Moment of a couple } M = P \times d = P \times AB$$



iii) Direction of a couple:-

A couple, having the tendency to rotate the body in the direction of hands of clock is clockwise couple

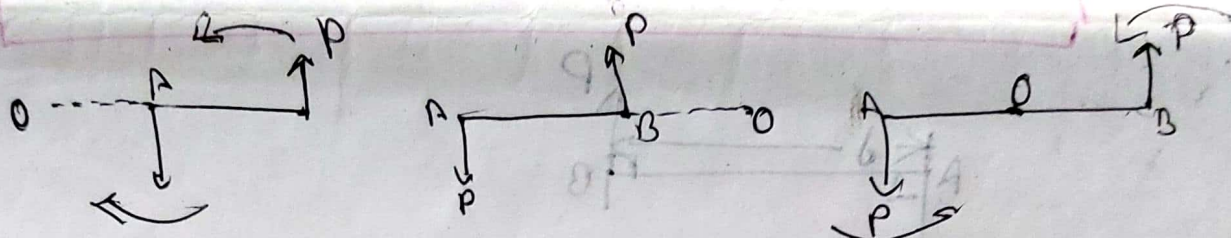
and a couple having the tendency to rotate the body in the direction, opposite to the hands of clock is called anticlockwise couple.



Theorems of a Couple

1st Theorem 1:-

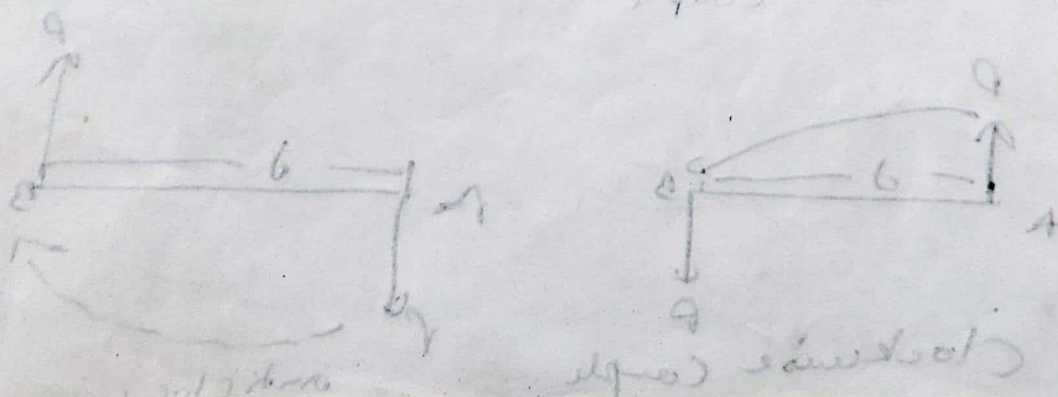
The algebraic sum of the moment of the forces, constituting a couple about any pt. in a plane will remain same and equal to the moment of couple itself.



$$P \times OB - P \times OA = P \times AB \quad -P \times OB + P \times OA = P \times AB \quad P \times OA + P \times OB = P \times AB$$

Theorem 2 \Rightarrow Resultant of many couples acting in the

Same plane will also equal to a couple, whose moment equal to algebraic sum of moments of all the couples.



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Theorem 3 Two equal and opposite couples acting on parallel planes, balance each other.

Theorem 4 If the three forces acting on a rigid body be represented, in magnitude as well as in direction, by the three sides of a triangle taken in order, then the forces are equivalent to a couple, whose moment is equal to twice the area of the triangle.

Silent Aspects of a Couple: Properties of a couple

- (i) A couple cannot be balanced by a single force. It can be balanced only by a couple of opposite sense.
- (ii) The algebraic sum of the vertical and horizontal components of the forces forming a couple is zero.
- (iii) A couple consists of a pair of equal and opposite forces separated by a definite distance.

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104. Any number of coplanar Couples can be reduced to a single couple of moment equal to the algebraic sum of moments of all the ~~couple~~ couples.

Theorem 2 Two equal and opposite couples acting in the same plane can be reduced to a single couple of moment equal to the algebraic sum of their moments.

Theorem 3 If the three forces acting on a rigid body are parallel and their lines of action are not concurrent, the body will be in equilibrium if and only if the algebraic sum of their moments about any point is zero.

Let the three forces be P, Q, R acting parallel to the XY -axis. Let their lines of action be at distances x, y, z from a point O on the XY -axis. Then the moments of P, Q, R about O are Px, Qy, Rz respectively. If the body is in equilibrium, the algebraic sum of these moments must be zero, i.e., $Px + Qy + Rz = 0$.

Theorem 4 A rigid body is in equilibrium if and only if the algebraic sum of the moments of all the forces acting on it about any point is zero.

Let a rigid body be acted upon by a number of forces $P_1, P_2, P_3, \dots, P_n$ acting at points $A_1, A_2, A_3, \dots, A_n$ respectively. Let O be any point in the plane of the forces. Let the distances of $A_1, A_2, A_3, \dots, A_n$ from O be $x_1, x_2, x_3, \dots, x_n$ respectively. Then the moments of $P_1, P_2, P_3, \dots, P_n$ about O are $P_1x_1, P_2x_2, P_3x_3, \dots, P_nx_n$ respectively. If the body is in equilibrium, the algebraic sum of these moments must be zero, i.e., $P_1x_1 + P_2x_2 + P_3x_3 + \dots + P_nx_n = 0$.