UNIT

1 **Basics of Mechanics and Force System**
(यांत्रिकी और बल प्रणाली की मूल बातें)

UNIT - I
Basics of Mechanics and Force System

Significance and relevance of mechanics, Applied mechanics, Statics, Dynamics. Space, time, mass, particle, flexible body and rigid body. Scalar and vector quantity, Units of measurement (SI units) Fundamental units and derived units.

Force - unit, representation as a vector and by Bow's notation, characteristics and effects of a force, Principle of transmissibility of force, Force system and its classification. Resolution of a force Orthogonal components of a force, moment of a force, Varignon's Theorem. Composition of forces Resultant, analytical method for determination of resultant for concurrent, non-concurrent and parallel co-planar force systems - Law of triangle, parallelogram and polygon of forces.

TOPICS

1. Mechanics (यान्त्रिकी)
2. Applied Mechanics (अनुप्रयुक्त यांत्रिकी)
3. Utility of Mechanics (यांत्रिकी की उपयोगिता)
4. Significance and relevance of Mechanics (यांत्रिकी का महत्व एवं प्रासंगिकता)
5. Branches of Engineering Mechanics(इंजीनियरिंग यांत्रिकी की शाखाएँ)

   (a) स्थैतिकी (Statics)

   (b) गतिकी (Dynamics)- (i) शुद्ध गतिकी (Kinematics) (ii) बल गतिकी (Kinetics)

6. Some of the definitions of the idealizations used in engineering mechanics

   (i) Space, (ii) time, (iii) mass, (iv) particle,

   (v) flexible body and (vi) rigid body

7. Scalar and vector quantity (अदिश तथा सदिश राशि)

8. Units of measurement (माप की इकाइयां)

9. Force (बल)

10. Representation of force (बल का निरूपण)

 (i) as a vector (सदिश के रूप में)   (ii) by Bow's notation (बो के संकेत द्वारा)

11. Characteristics of force (बल के लक्षण)

12. Effects of force (बल के प्रभाव)

13. Principle of transmissibility of force (बलों के स्थानांतरणशीलता का सिद्धान्त)

✓14. Force system and its classification (बल निकाय तथा इसका वर्गीकरण)

15. Resultant Force (परिणामी बल)

16. Determination of resultant Force (परिणामी बल ज्ञात करना)

    (i) Analytical method (विश्लेषण विधि)

    (ii) Graphical Method (ग्राफीय विधि)

17. Law of parallelogram of forces (बलों के समांतर चतुर्भुज का नियम)

18. Resolution of a force (बलों का वियोजन)

19. Law of triangle of forces (बलों के त्रिभुज का नियम)

20. Law of Polygon of forces (बल बहुभुज का नियम)

21. Lami's Theorem (लामी का प्रमेय)

22. Free body Diagram (मुक्त पिण्ड आरेख)

23. moment of a force (बल आघूर्ण)

24. Varignon's Theorem (वैरिग्नॉन प्रमेय)

Calculator
↳ Casio
f_x- 991 MS

Case-1 :- यदि $\theta = 0°$ (F1 & F2 are Parallel Force(समांतर बल)) तब

∵ परिणामी बल (Resultant force) :-

$$R = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta}$$

$$R = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos0°}$$

$$R = \sqrt{F_1^2 + F_2^2 + 2F_1 \cdot F_2 \times 1}$$
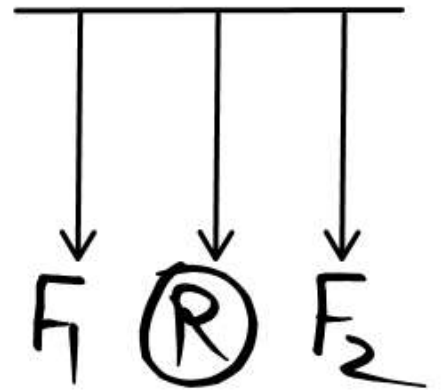
$$R = \sqrt{(F_1 + F_2)^2}$$

$$\boxed{R = F_1 + F_2}$$

परिणामी की दिशा (Direction of Resultant)

$$\tan\alpha = \frac{F_2\sin\theta}{F_1 + F_2\cos\theta}$$

$$\tan\alpha = \frac{F_2\sin0°}{F_1 + F_2\cos0°}$$

$$\tan\alpha = \frac{F_2 \times 0}{F_1 + F_2 \times 1}$$

$$\boxed{\alpha = 0°}$$

$\overset{\downarrow}{F_1} \quad Ⓡ \quad \overset{\downarrow}{F_2}$

Case-2 :- यदि θ = 90° (F1 & F2 are perpendicular Force(लंबवत बल)) तब

परिणामी बल (Resultant Force)

$$R = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta}$$

$$R = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos90°}$$

$$R = \sqrt{F_1^2 + F_2^2 + 2F_1F_2 \times 0}$$
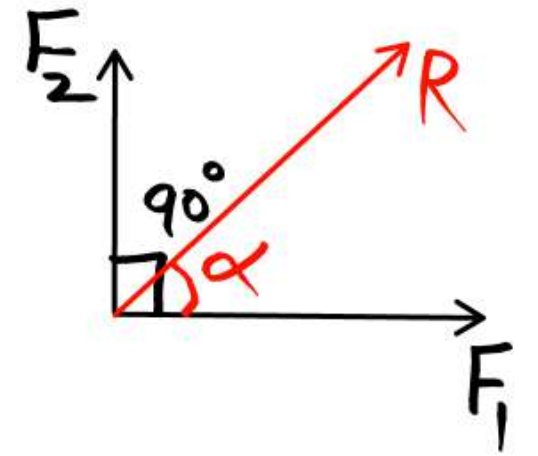
$$\boxed{R = \sqrt{F_1^2 + F_2^2}}$$

दिशा (Direction)

$$\tan\alpha = \frac{F_2\sin\theta}{F_1 + F_2\cos\theta}$$

$$\tan\alpha = \frac{F_2\sin90°}{F_1 + F_2\cos90°}$$

$$\tan\alpha = \frac{F_2 \times 1}{F_1 + F_2 \times 0}$$

$$\tan\alpha = \frac{F_2}{F_1} \Rightarrow \boxed{\alpha = \tan^{-1}\left(\frac{F_2}{F_1}\right)}$$

Case-3 :- यदि θ = 180° (F1 & F2 are Opposite Force(विपरीत बल)) तब

परिणामी बल (Resultant force) :-

$$R = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta}$$

$$R = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos180°}$$

$$R = \sqrt{F_1^2 + F_2^2 + 2F_1F_2 \times (-1)}$$

$$R = \sqrt{F_1^2 + F_2^2 - 2F_1F_2}$$

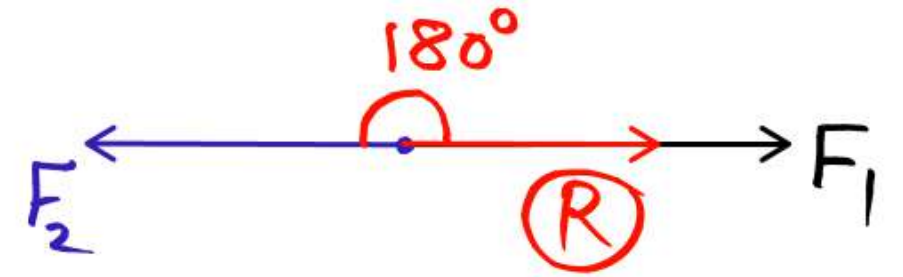$$R = \sqrt{(F_1 - F_2)^2} \Rightarrow \boxed{R = F_1 - F_2}$$

दिशा (Direction)

$$\tan\alpha = \frac{F_2 \sin\theta}{F_1 + F_2 \cos\theta}$$

$$\tan\alpha = \frac{F_2 \sin180°}{F_1 + F_2 \cos180°}$$

$$\tan\alpha = \frac{F_2 \times 0}{F_1 + F_2 \times (-1)}$$

$$\boxed{\alpha = 0°}$$

180°

F_2 ← R → F_1

Case-4 :- यदि F1 = F2 (F1 & F2 are Equal Force(समान बल)) तब

परिणामी बल (Resultant Force)

माना $F_1 = F_2 = F$

$$R = \sqrt{F_1^2 + F_2^2 + 2F_1F_2 \cos\theta}$$

$$R = \sqrt{F^2 + F^2 + 2F \cdot F \cos\theta}$$

$$R = \sqrt{2F^2 + 2F^2 \cos\theta}$$

$$R = \sqrt{2} \cdot F \left(\sqrt{1 + \cos\theta}\right)$$

$$R = \sqrt{2} \cdot F \sqrt{1 + 2\cos^2\frac{\theta}{2} - 1}$$

$$R = \sqrt{2} \cdot F \times \sqrt{2}\cos\frac{\theta}{2}$$

$$\boxed{R = 2F \cdot \cos\frac{\theta}{2}}$$

दिशा (Direction)

$$\tan\alpha = \frac{F_2 \sin\theta}{F_1 + F_2 \cos\theta}$$

$$\tan\alpha = \frac{F \sin\theta}{F + F\cos\theta}$$

$$\tan\alpha = \frac{F \sin\theta}{F(1 + \cos\theta)}$$

$$\tan\alpha = \frac{2\sin\frac{\theta}{2} \cdot \cos\frac{\theta}{2}}{1 + 2\cos^2\frac{\theta}{2} - 1}$$

$$\tan\alpha = \tan\frac{\theta}{2}$$

$$\boxed{\alpha = \frac{\theta}{2}}$$

Q.1:- चित्र में दर्शाये गये बल निकाय के परिणामी बल का परिमाण तथा दिशा ज्ञात कीजिए।

Find the magnitude and direction of the resultant force of the force system shown in the figure.
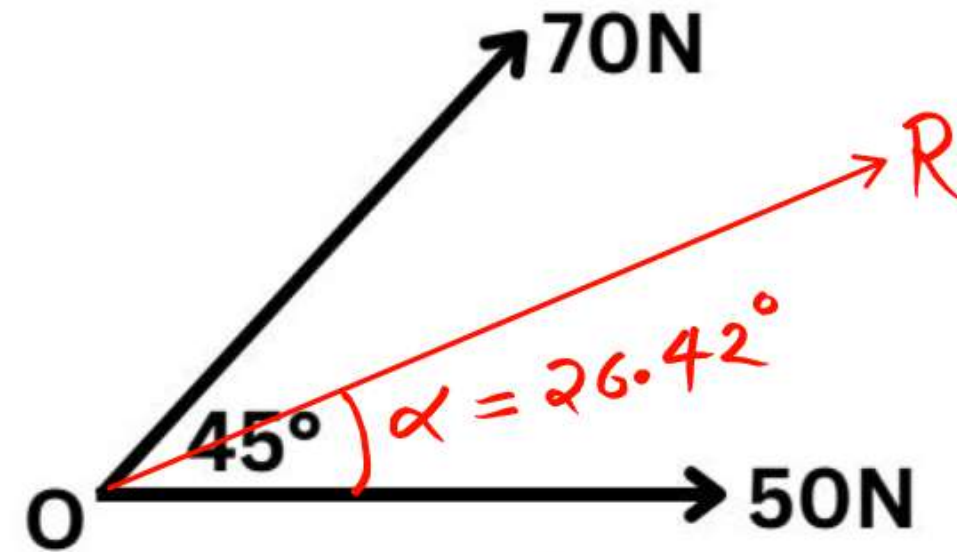
माना $F_1 = 50N$ & $F_2 = 70N$

& $\theta = 45°$

परिणामी बल (Resultant Force)

$$R = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta}$$

$$R = \sqrt{50^2 + 70^2 + 2 \times 50 \times 70 \times \cos 45°}$$

$$\boxed{R = 111.129N} \quad \underline{Ans}$$

70N

R

$\alpha = 26.42°$

45°

O — 50N

दिशा (Direction)

$$\tan\alpha = \frac{F_2 \sin\theta}{F_1 + F_2 \cos\theta}$$

$$\tan\alpha = \frac{70 \sin 45°}{50 + 70 \cos 45°}$$

$$\tan\alpha = 0.497$$

$$\alpha = \tan^{-1}(0.497)$$

$$\boxed{\alpha = 26.42°}$$

Q.2:- दो बलों जिनका परिमाण 240N और 200N है, एक बिन्दु O पर क्रियाशील हैं जैसा कि चित्र में दर्शाया गया है। यदि बलों के बीच 30° का कोण है तो उनका परिणामी बल ज्ञात कीजिए तथा चित्र में दिखाये अनुसार कोण β और γ का मान भी ज्ञात कीजिए।

Two forces of magnitude 240N and 200N are acting at a point O as shown in the figure. If there is an angle of 30° between the forces then find their resultant force and also find the value of angles β and γ as shown in the figure.
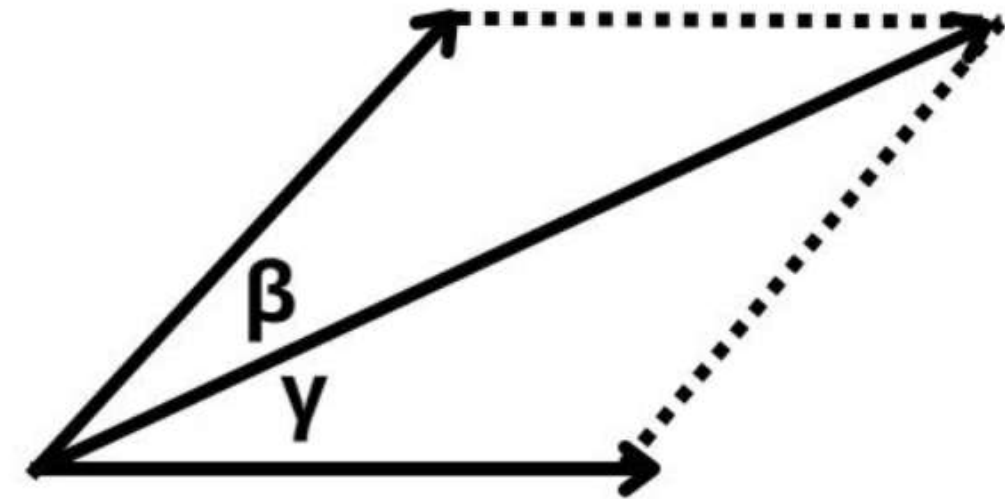
Q.3 :- 60° पर लगे हुए दो बलों का परिणामी 14N है। यदि वही बल समकोण पर लगे हो तब परिणामी √(136) N है। दोनों बलों का परिमाण ज्ञात कीजिए ।

The resultant of two forces acting at 60° is 14N. If the same force is applied at right angles then the resultant is √(136) N. Find the magnitude of both the forces.