INTRODUCTION

University of Diyala
College of Engineering

Engineering Mechanics
Statics & Dynamics

First Glass

Dep. Of Electrical power Eng.

Lecturer

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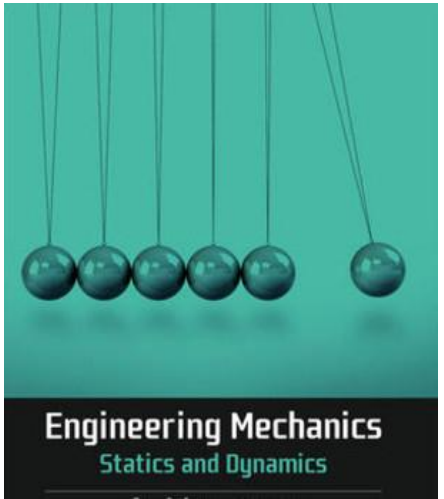
2017-2018



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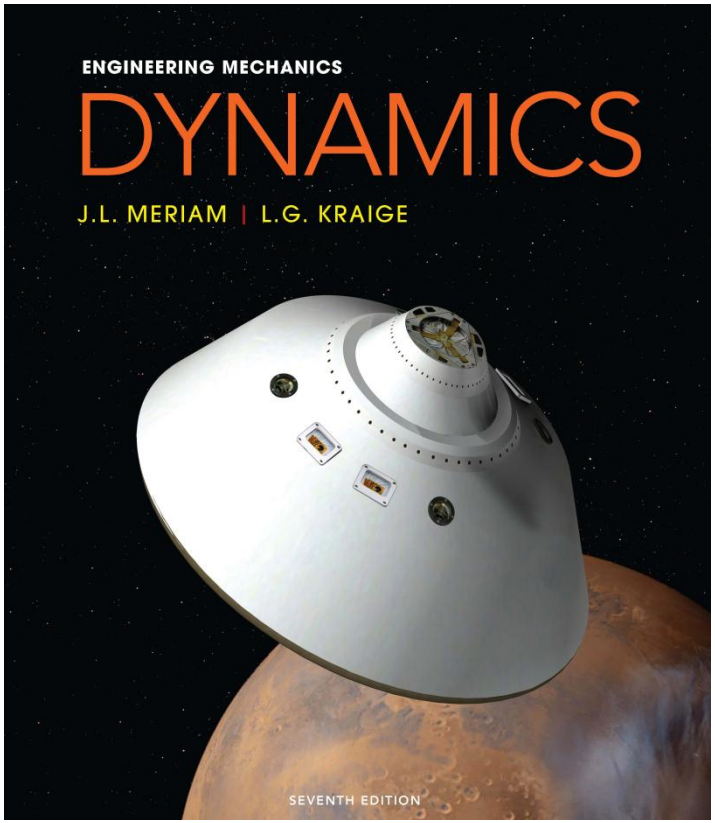
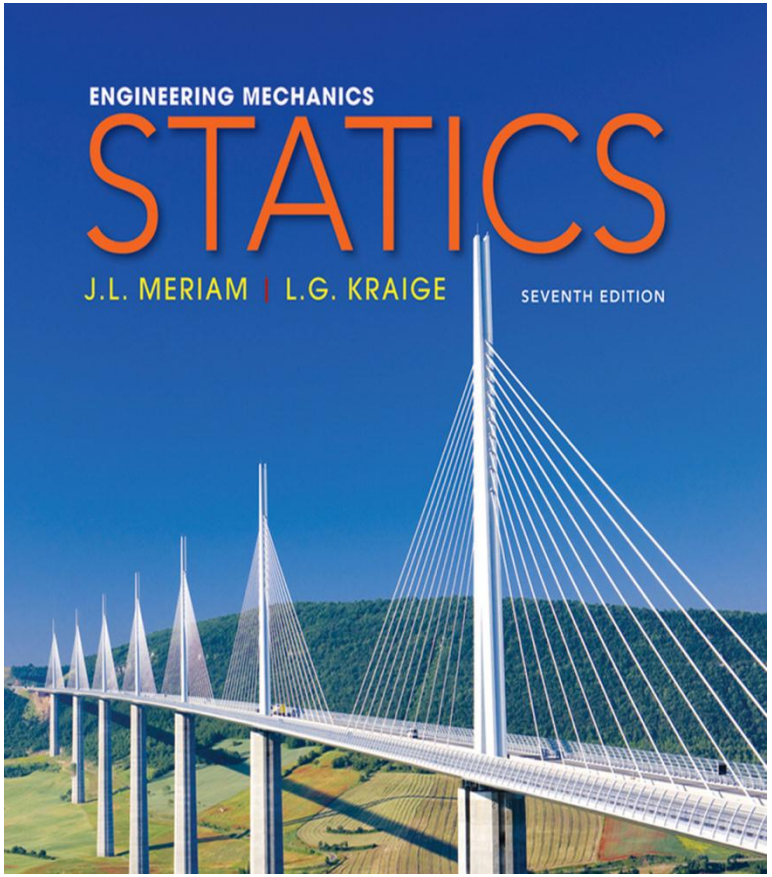
- **Text Book**

Engineering mechanics Statics & Dynamics. 6th. (2010). J. L. MERIAM L. G. KRAIGE





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- **Other books of Engineering Mechanics**

1. Engineering mechanics statics &dynamics. 3th. Archie higdon.
2. Vector mechanics for engineering Ferdinand P. peer. 7th
3. Vector mechanics for engineering Ferdinand L. singer. 2th
4. Introduction of mechanics of solids. Egor. P. popov.
5. Engineering mechanics statics 12th. R. C. Hibbeler.
6. Theory and Problems of Engineering mechanics statics &dynamics. 5th Scaum's outhine.

Preface

- Engineering mechanics is both a foundation and a framework for most of the branches of engineering.
- Engineering mechanics based upon the subjects of statics and dynamics.
- Even in a discipline such as electrical engineering, and inter in the electrical components of a robotic device or a manufacturing process.
- to solidify the student's understanding of other important subjects, including applied mathematics, physics, and graphics.

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primary purpose of Engineering Mechanics

- to develop the capacity to predict the effects of force and motion.
- This capacity requires more than a mere knowledge of the physical and mathematical principles of mechanics.
- Also required is the ability to visualize physical configurations in terms of real materials, actual constraints, and the practical limitations which govern the behavior of machines and structures

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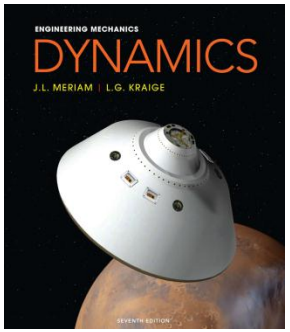
Categories of Mechanics:

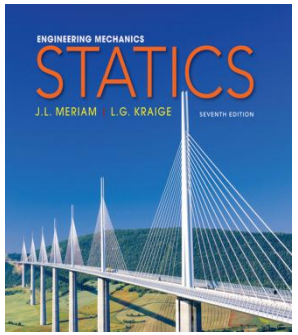
- The subject of mechanics is logically divided into two parts:
- ***statics***, which concerns the equilibrium of bodies under action of forces, and
- ***dynamics***, which concerns the motion of bodies.

Engineering Mechanics is divided into these two parts,

Vol. 1 Statics.

Vol. 2 Dynamics.





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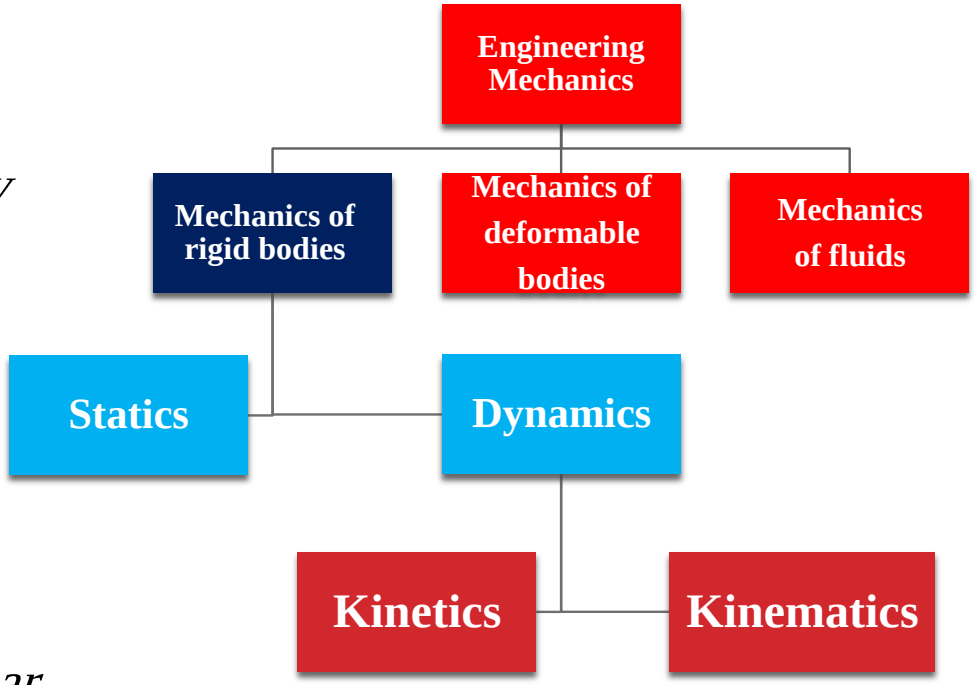
Statics

- *Force system*
- *Equilibrium*
- *Friction*
- *Centroids & center of gravity centroids*



Dynamics

- *Kinetics of practical*
- *Rectilinear motion, curvilinear motion,…….*
- *Kinetics: force, mass, and acceleration,……..*
- *Kinetics of practical Newton's* 2^{th} *law*

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❖ Fundamental Concepts

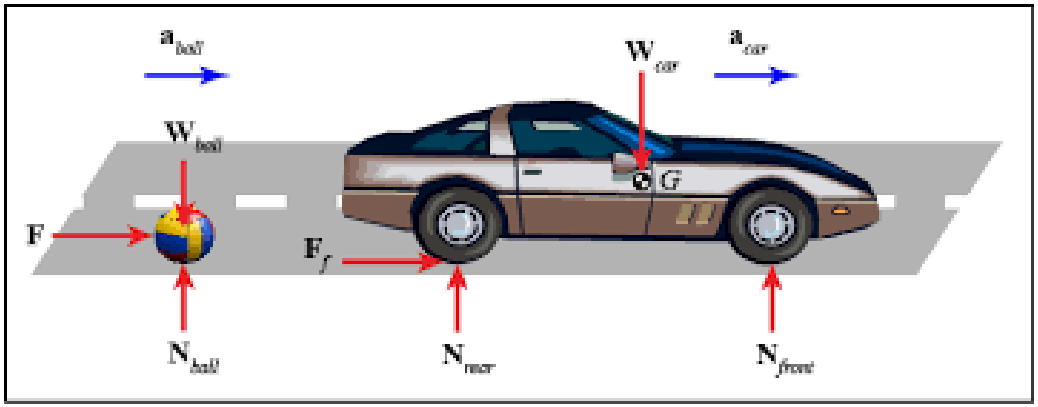
- ***Space*** - associated with the notion of the position of a point P given in terms of three coordinates measured from a reference point or origin.
- ***Time*** - definition of an event requires specification of the time and position at which it occurred.
- ***Mass*** - used to characterize and compare bodies, e.g., response to earth's gravitational attraction and resistance to changes in translational motion.
- ***Force*** - represents the action of one body on another. A force is characterized by its point of application, magnitude, and direction, i.e., a force is a vector quantity.

In Newtonian Mechanics, space, time, and mass are absolute concepts, independent of each other. Force, however, is not independent of the other three. The force acting on a body is related to the mass of the body and the variation of its velocity with time.

❖ Fundamental Concepts

A particle is a body of negligible dimensions. In the mathematical sense, a particle is a body whose dimensions are considered to be near zero so that we may analyze it as a mass concentrated at a point.

Rigid body. A body is considered rigid when the change in distance between any two of its points is negligible for the purpose at hand.



Units

QUANTITY	DIMENSIONAL SYMBOL	SI UNITS		U.S. CUSTOMARY UNITS	
		UNIT	SYMBOL	UNIT	SYMBOL
Mass	M	kilogram	kg	slug	—
Length	L	Base meter*	m	Base foot	ft
Time	T	units second	s	units second	sec
Force	F	newton	N	pound	lb

Unnumbered Table p7a

SI UNITS

$$(1\ \mathrm{N}) = (1\ \mathrm{kg})(1\ \mathrm{m/s^2})$$
$$\mathrm{N} = \mathrm{kg \cdot m/s^2}$$

U.S. CUSTOMARY UNITS

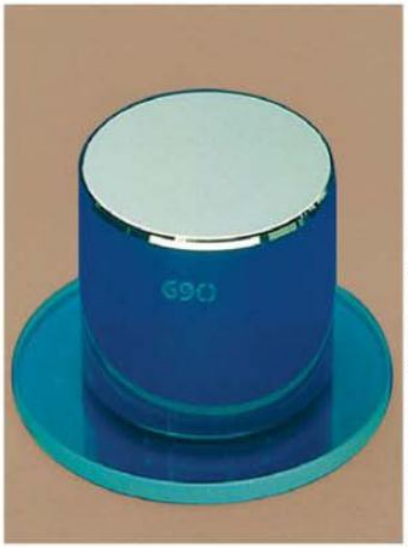
$$(1\ \mathrm{lb}) = (1\ \mathrm{slug})(1\ \mathrm{ft/sec^2})$$
$$\mathrm{slug} = \mathrm{lb \cdot sec^2/ft}$$

Unnumbered Table p7b

Units

TABLE 1–2 Conversion Factors

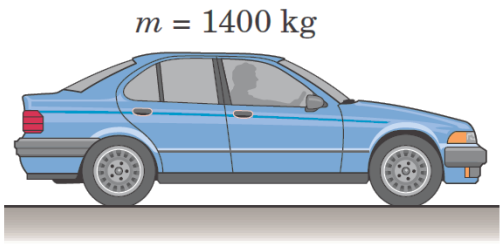
Quantity	Unit of Measurement (FPS)	Equals	Unit of Measurement (SI)
Force	lb		4.448 N
Mass	slug		14.59 kg
Length	ft		0.304 8 m



The standard kilogram

Ex: Determine the weight in newton's of a car whose mass is 1400 kg.
Convert the mass of the car to slugs and then determine its weight in pounds.

$$W = mg = 1400(9.81) = 13\ 730\ \text{N}$$



$$m = 1400\ \text{kg}\left[\frac{1\ \text{slug}}{14.594\ \text{kg}}\right] = 95.9\ \text{slugs}$$

$$W = mg = (95.9)(32.2) = 3090\ \text{lb}$$

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❖ Fundamental principles

Newton's Laws

- ***Newton's First Law***: If the resultant force on a particle is zero, the particle will remain at rest or continue to move in a straight line.

- ***Newton's Second Law***: A particle will have an acceleration proportional to a nonzero resultant applied force.

$$\vec{F} = m\vec{a}$$

- ***Newton's Third Law***: The forces of action and reaction between two particles have the same magnitude and line of action with opposite sense.

- ***Newton's Law of Gravitation***: Two particles are attracted with equal and opposite forces,

$$F = G\frac{Mm}{r^2} \qquad W = mg, \quad g = \frac{GM}{R^2}$$

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❖ Scalars and Vectors

We use two kinds of quantities in mechanics—scalars and vectors.

Scalar quantities are those with which only a magnitude is associated. Examples of scalar quantities are time, volume, density, speed, energy, and mass.

Vector quantities. It's a quantity having magnitude and direction and which conforms to the parallogram of triangle laws.
Examples of vector quantities are displacement, velocity, acceleration, force, moment, and momentum.

Speed is a scalar. It is the magnitude of velocity, which is a vector. Thus velocity is specified by a direction as well as a speed.

❖ *Vector quantities.*

- The direction of the vector **V** may be measured by an angle from some known reference direction as shown in Fig. 1/1.

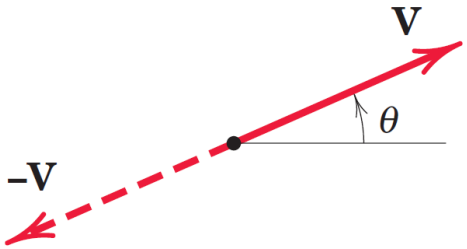


Figure 1/1

- Vectors must obey the parallelogram law of combination. This law states that two vectors **V**1 and **V**2, treated as free vectors, Fig. 1/2*a*

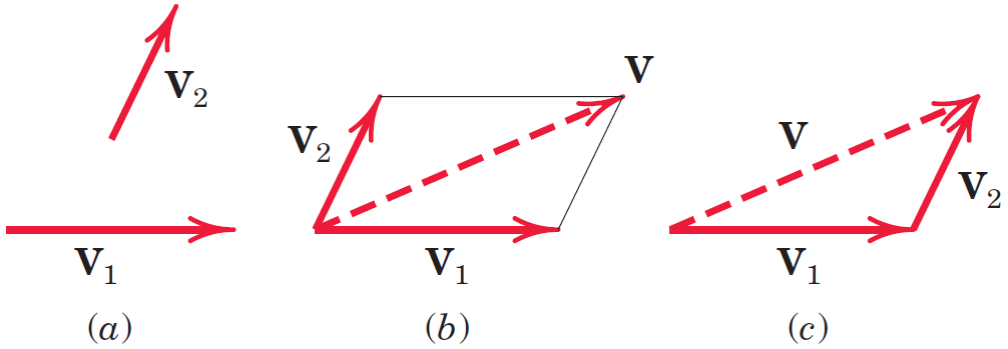
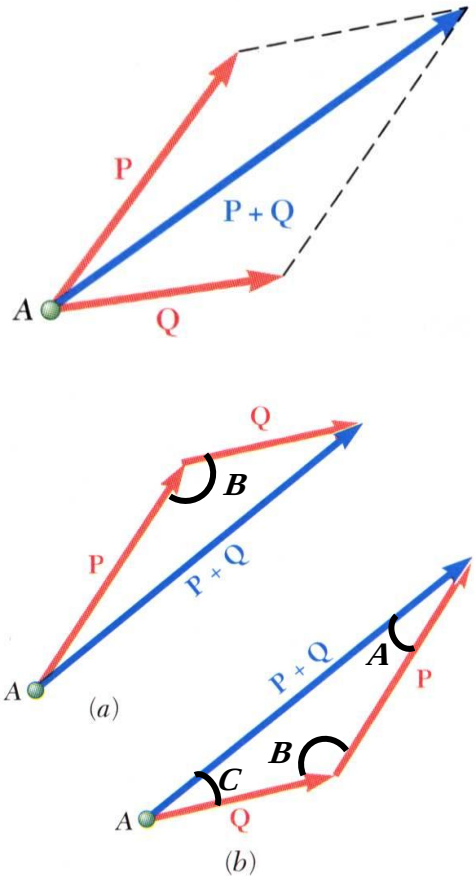


Figure 1/2

$$\mathbf{V} = \mathbf{V}_1 + \mathbf{V}_2$$

❖ *Addition of Vectors*



- Law of cosines,

$$R^2 = P^2 + Q^2 - 2PQ\cos B$$
$$\vec{R} = \vec{P} + \vec{Q}$$

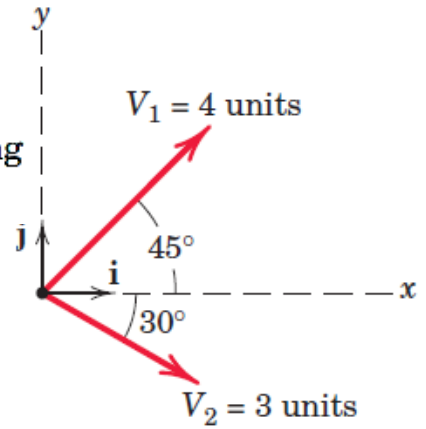
- Law of sines,

$$\frac{\sin A}{Q} = \frac{\sin B}{R} = \frac{\sin C}{p}$$

For the vectors $\mathbf{V}_1$ and $\mathbf{V}_2$ shown in the figure,

(*a*) determine the magnitude S of their vector sum $\mathbf{S} = \mathbf{V}_1 + \mathbf{V}_2$

(*b*) determine the angle α between $\mathbf{S}$ and the positive x-axis



Solution (*a*) We construct to scale the parallelogram shown in Fig. *a* for adding $\mathbf{V}_1$ and $\mathbf{V}_2$. Using the law of cosines, we have

$$S^2 = 3^2 + 4^2 - 2(3)(4)\cos 105°$$

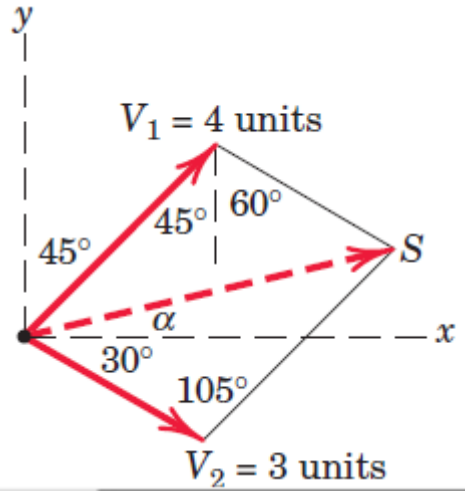
$$S = 5.59 \text{ units}$$

(*b*) Using the law of sines for the lower triangle, we have

$$\frac{\sin 105°}{5.59} = \frac{\sin(\alpha + 30°)}{4}$$

$$\sin(\alpha + 30°) = 0.692$$

$$(\alpha + 30°) = 43.8° \qquad \alpha = 13.76°$$



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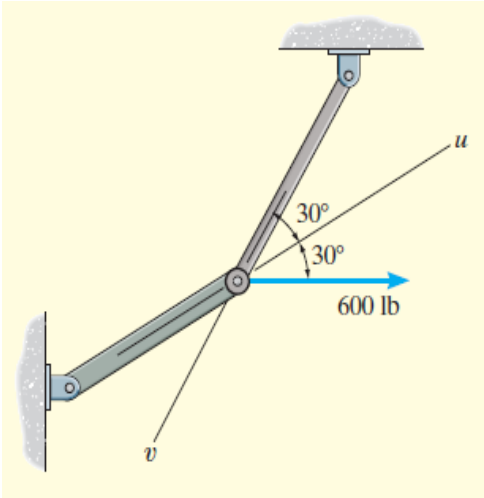
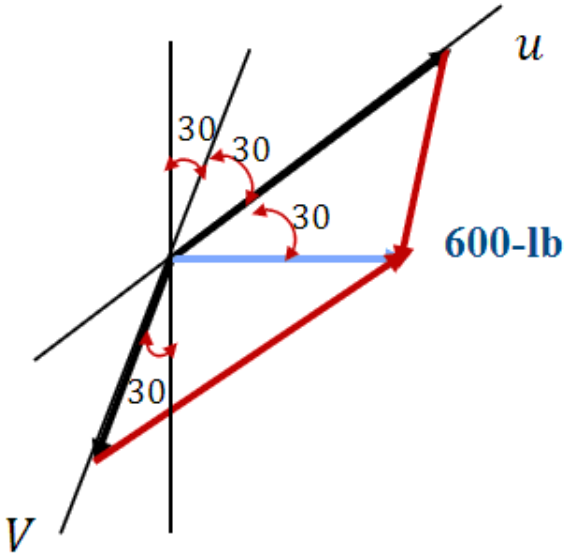
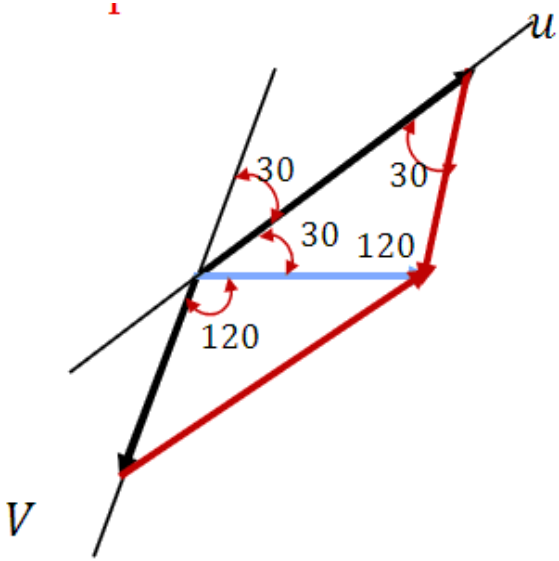
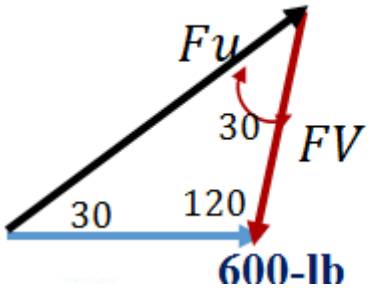
Ex :- Resolve the horizontal **600-lb** force in Fig. into components acting along the *u* and *v* axes and determine the magnitudes of these components.









$$\frac{Fu}{\sin 120} = \frac{600\ lb}{\sin 30}$$

Fu = 1093 lb.

$$\frac{Fv}{\sin 30} = \frac{600\ lb}{\sin 30}$$

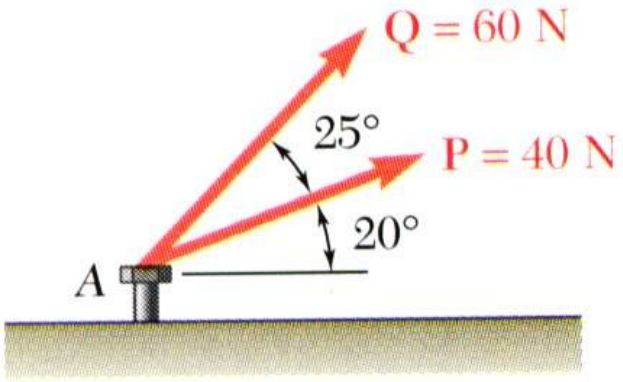
Fv = 600 lb.

From the Law of Cosines,

$$R^2 = P^2 + Q^2 - 2PQ\cos B$$

$$= (40\,\text{N})^2 + (60\,\text{N})^2 - 2(40\,\text{N})(60\,\text{N})\cos 155°$$

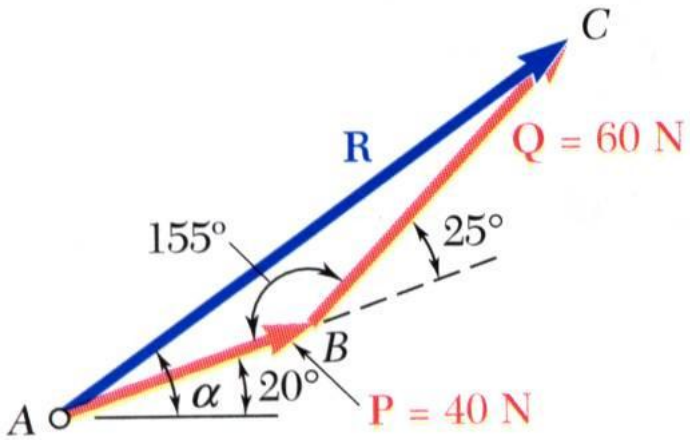
$$\boxed{R = 97.73\,\text{N}}$$



From the Law of Sines,

$$\frac{\sin A}{Q} = \frac{\sin B}{R} \qquad \sin A = \sin B\,\frac{Q}{R}$$

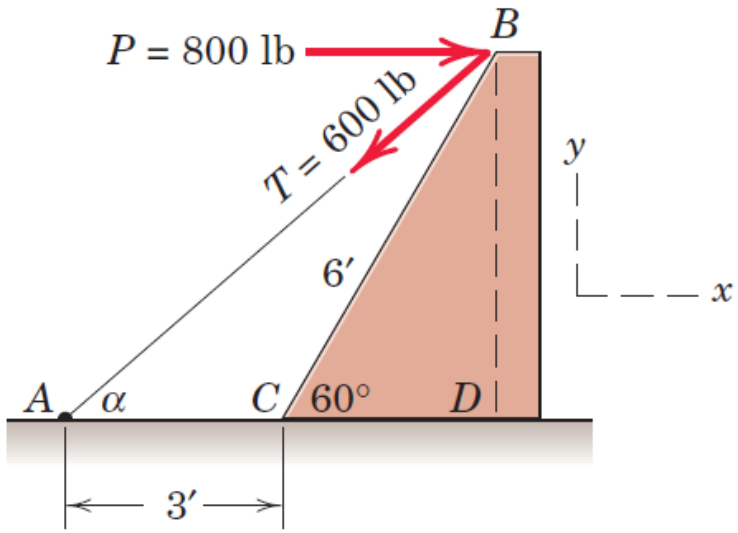
$$= \sin 155°\,\frac{60\,\text{N}}{97.73\,\text{N}}$$



$$A = 15.04° \qquad \alpha = 20° + A$$

$$\boxed{\alpha = 35.04°}$$

Ex:- Combine the two forces **P** and **T**, which act on the fixed structure at *B*, into a single equivalent force **R**.



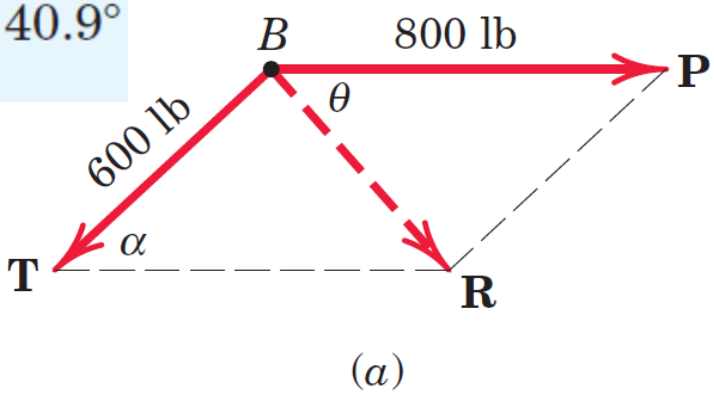
$$\tan\alpha = \frac{\overline{BD}}{\overline{AD}} = \frac{6\sin 60°}{3 + 6\cos 60°} = 0.866$$

$$\alpha = 40.9°$$

$$R^2 = (600)^2 + (800)^2 - 2(600)(800)\cos 40.9°$$

$$= 274{,}300$$

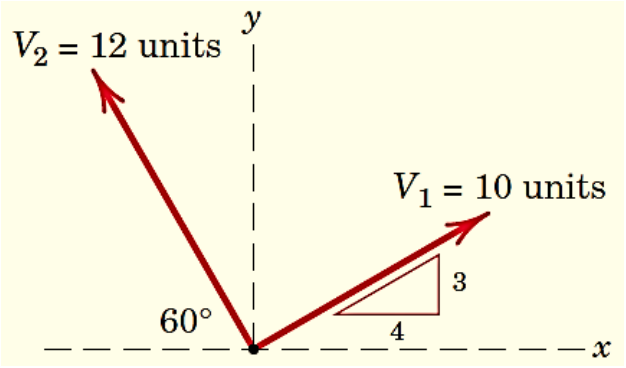
$$R = 524 \text{ lb}$$



(a)

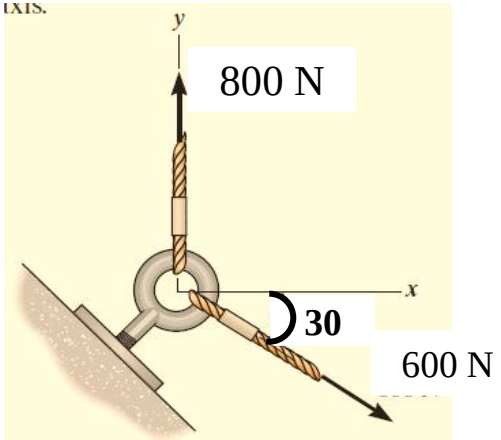
H.w

Q1/ Determine the magnitude of the vector sum $v = v_1 + v_2$ and the angle θ_x which v makes with the positive x-axis. Complete both graphical and algebraic solutions.



Q2/ What is the mass in both slugs and kilograms of a 3000-lb car ?

Q3/ Determine the magnitude of the resultant force and its direction measured counterclockwise from the positive x axis.



Q4:- The guy cables ***AB*** and ***AC*** are attached to the top of the transmission tower. The tension in cable ***AC*** is **8 kN**. Determine the required tension ***T*** in cable ***AB*** such that the net effect of the two cable tensions is a downward force at point ***A***. Determine the magnitude ***R*** of this downward force.