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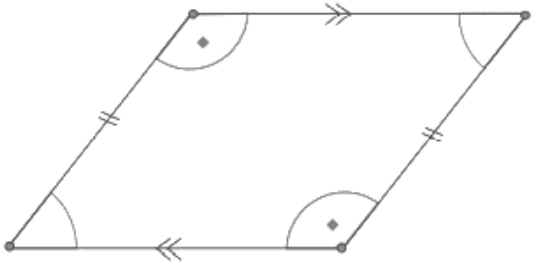
<tr><td>AIMS OF LESSON</td><td colspan="2">At the end of this lesson you should be able:
• To determine the resultant force by making use of the parallelogram law of forces.</td></tr>
<tr><td rowspan="2">RESOURCES</td><td>Paper based resources</td><td>Digital resources</td></tr>
<tr><td>Gr 11 Technical Sciences Textbook Pages 41 to 47</td><td>https://www.youtube.com/watch?v=NJgAUWHHk-s</td></tr>
<tr><td>INTRODUCTION</td><td colspan="2">In the previous lesson you learned different ways to determine the resultant force of two forces acting on a point. You have used the head to tail method and the theorem of Pythagoras. In this lesson you are going to determine the resultant force by making use of the parallelogram law of forces.</td></tr>
<tr><td>CONCEPTS AND SKILLS</td><td>A parallelogram is a quadrilateral with two pairs of opposite sides equal and parallel, and two pair of interior opposite angles equal.

The Parallelogram Law of Forces.
This law states that if two forces acting at a point can be represented by the adjacent sides of a parallelogram both in magnitude and direction, then the diagonal from the point gives the resultant of the two forces.

Sometimes a number of vectors act in directions that are non-perpendicular to each other. Then you cannot use the theorem of Pythagoras to determine the resultant force. The Parallelogram Law of Forces comes in handy to solve the problem.</td><td>CAN YOU?
• Work with bearing
• Draw vertical and horizontal lines
• Work from a reference point
• Use a protractor to measure accurate angles.
• Work out a scale and apply it.
• Complete a parallelogram.</td></tr>
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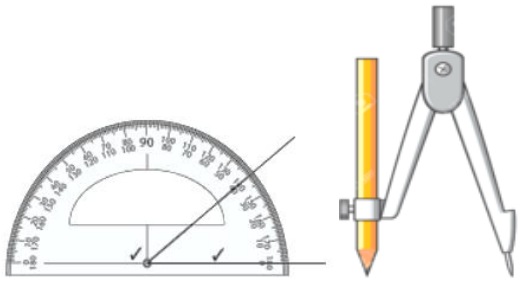
Tools that you will use:



STEPS TO COMPLETE A PARALLELOGRAM

1. Choose an appropriate scale.
2. Draw a reference line and point.
3. Determine the direction and magnitude of the forces.
4. Draw forces according to bearing and magnitude.
5. Complete the parallelogram. You can either use the angles or the sides of the parallelogram.

Example 1

Use the Parallelogram Law of Forces to find the resultant of two forces F_1 = 60 N and F_1 = 45 N acting simultaneously at a point, and separated by the angle of 60˚.

Solution

Step 1

Choose a suitable scale that you can use to convert Newton to cm.

Eg. 1 cm : 5 N.

F_1 - 12 cm : 60 N

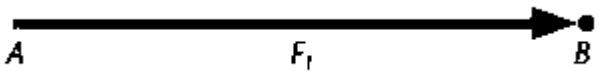
F_2 - 9 cm : 45 N.

Step 2

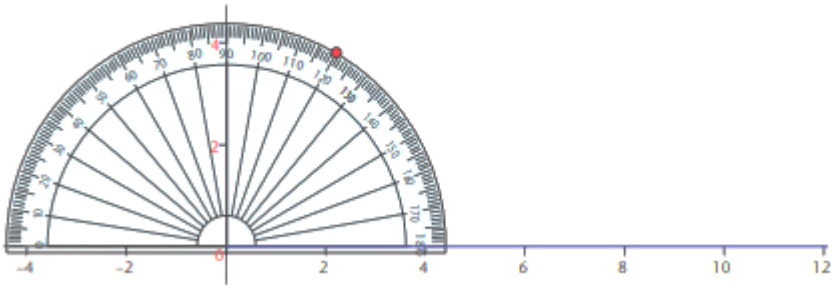
Draw F_1 according to scale , represented by the horizontal-arrowed line (vector)

Step 3:

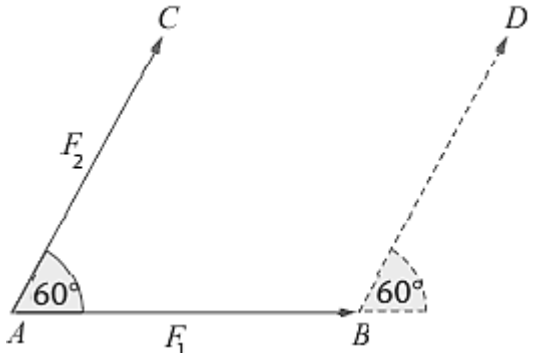
Label this line AB.



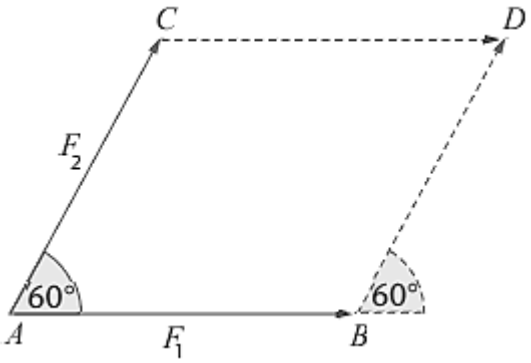
Step 4:
From the tail of this force, measure an angle of 60˚, and draw the second arrowed-line



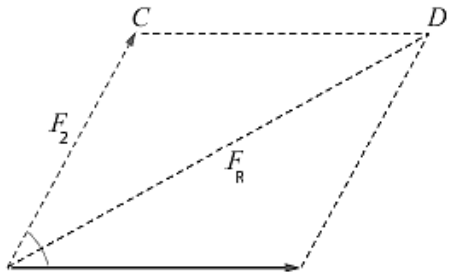
Step 5:
From the head of the force AB, measure an angle of 60˚ and construct a dotted line through that angle. Label that line BD, of the same magnitude as force AC. BD must be parallel and equal in magnitude to AC.



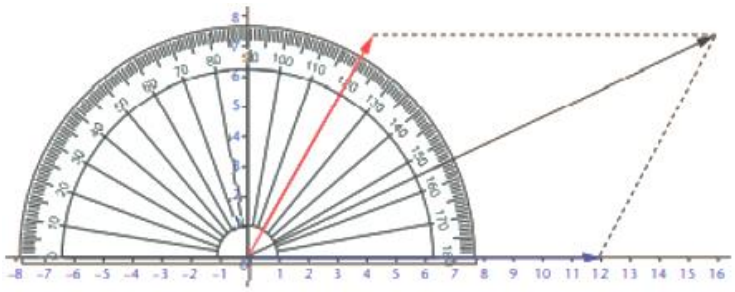
Step 6:
Join CD with a dotted line. Note that DC will be automatically equal in magnitude and parallel to AB.



Step 7:
Join AD. Notice that, according to the parallelogram of forces theorem, this diagonal is the resultant of the F_1 and F_2.



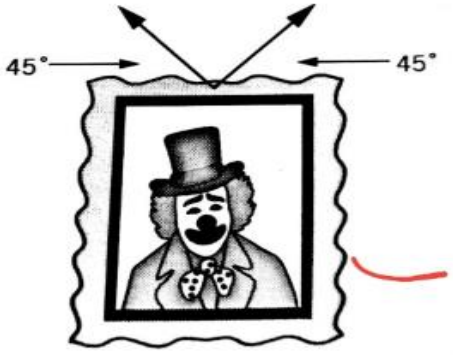
Step 8:
Use a ruler to measure the length of the diagonal.
Now use your scale to convert it to Newton and find the magnitude of the resultant force.
Measure the angle made by the resultant with the horizontal, to get its direction.

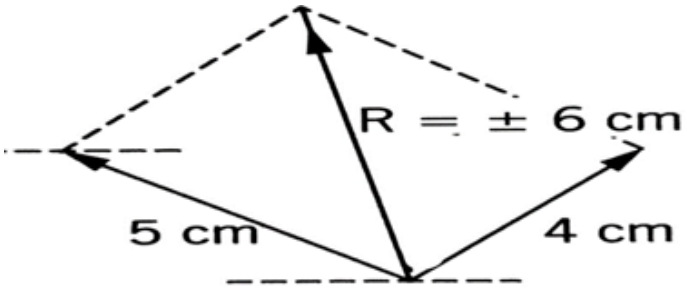


Step 8:
The length of the vector representing the resultant force is about 18,3 cm.
1 cm : 5 N
Thus 18,3 cm=-91,5 N
F_R = 91,5 N, and its direction is 25˚ from the horizontal.

Example 2

A Painting is being held up by two ropes. The force in the rope on the left-side is 50N and the force in the rope on the right is 40N. The direction between the ropes and painting is shown in the diagram.
Please notice that the force act upon a horizontal surface. That is why my reference line will also be a horizontal line.



	Solution Scale **=** 1cm : 10N  The diagonal is 346º from North (0º) and 6cm in magnitude. The scale is 1cm:10N Therefore the resultant force (F_R) is 60N at 346º Use the Parallelogram Law of forces to see if you get the same answer.
ACTIVITIES/ ASSESSMENT	Consult your Technical Sciences textbook and complete the following: Exercise 1.10 Pages 44 to 45.
CONSOLIDATION	You should now be able to: • Use a protractor accurately to measure angles • Draw forces to scale • Complete a parallelogram • Determine the resultant force of two forces that are perpendicular to one another and forces that are non- perpendicular.
VALUES	Make sure that your stationary is in a good condition before you start (pencil is sharp, protractor is clean etc.) As far as possible use your own stationary to protect yourself and others and always work as accurate as possible.