# Exercise 5: Forces as vectors

Purpose: To investigate the vector properties of forces by balancing hanging masses.

__Introduction__

You will be experimenting with a force table (shown in the figure below) to attain a better understanding of vectors. It is a round table with a center pin and angle divisions marked around its outside edge. A ring is placed around the center pin that has strings attached to it, and the strings are run over pulleys at different locations around the table. The strings are connected to hangers beyond the edge of the force table. Masses can be added to the hangers to increase the tension in the strings (be sure to include the mass of the hanger itself as part of the hanging mass).
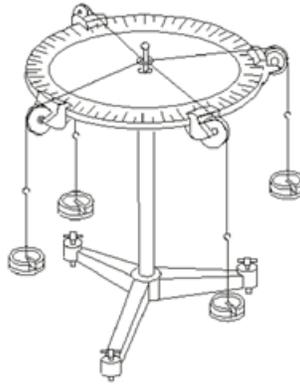
Each string will exert a force on the ring that is proportional to the mass hung on it and in a direction along the line of the string. Notice that force is a vector quantity. Since it has direction as well as magnitude, it is possible for two or more non-zero forces to balance out to a zero net force.

We will also be drawing diagrams of the forces in two dimensions as they appear when looking down at the force table. Three forces are shown in the diagram below; one of magnitude 0.20 N pointing at 0º, one of magnitude 0.40 N pointing at 90º, and one of magnitude 0.45 N pointing at 243º. These three vectors add up to a zero net force. Thus, the ring would be centered on the force table.

For the remainder of this lab, you will be given sets of forces and be asked to solve for the force(s) needed to cancel them out. You will then test your predictions on the force table. You will also need to sketch all of the force vectors on the diagrams provided. Be sure to sketch the vectors such that their *lengths are proportional to their magnitudes*.

Some final advice before beginning the assignment:

- Be sure that your calculator is not in radians mode while inputting arguments in degrees.
- When using inverse trigonometric functions, be sure that the angle you find is in the correct quadrant.

Laboratory assignment

1. Calculate the values for the missing cells in the table.
2. Test your calculations by placing masses on the force table. Is it balanced?
3. If the force table is balanced, then fill in the missing cells in the table.
4. Draw appropriate vectors in the vector diagram wheel.
5. Make copies of the diagrams and tables in your lab book. Then ask the instructor to see your results and the balanced force table.
6. Continue onto the next force problem and repeat steps 1-5.

Equipment list: Force table, ring, strings, mass hanger, slotted weights.
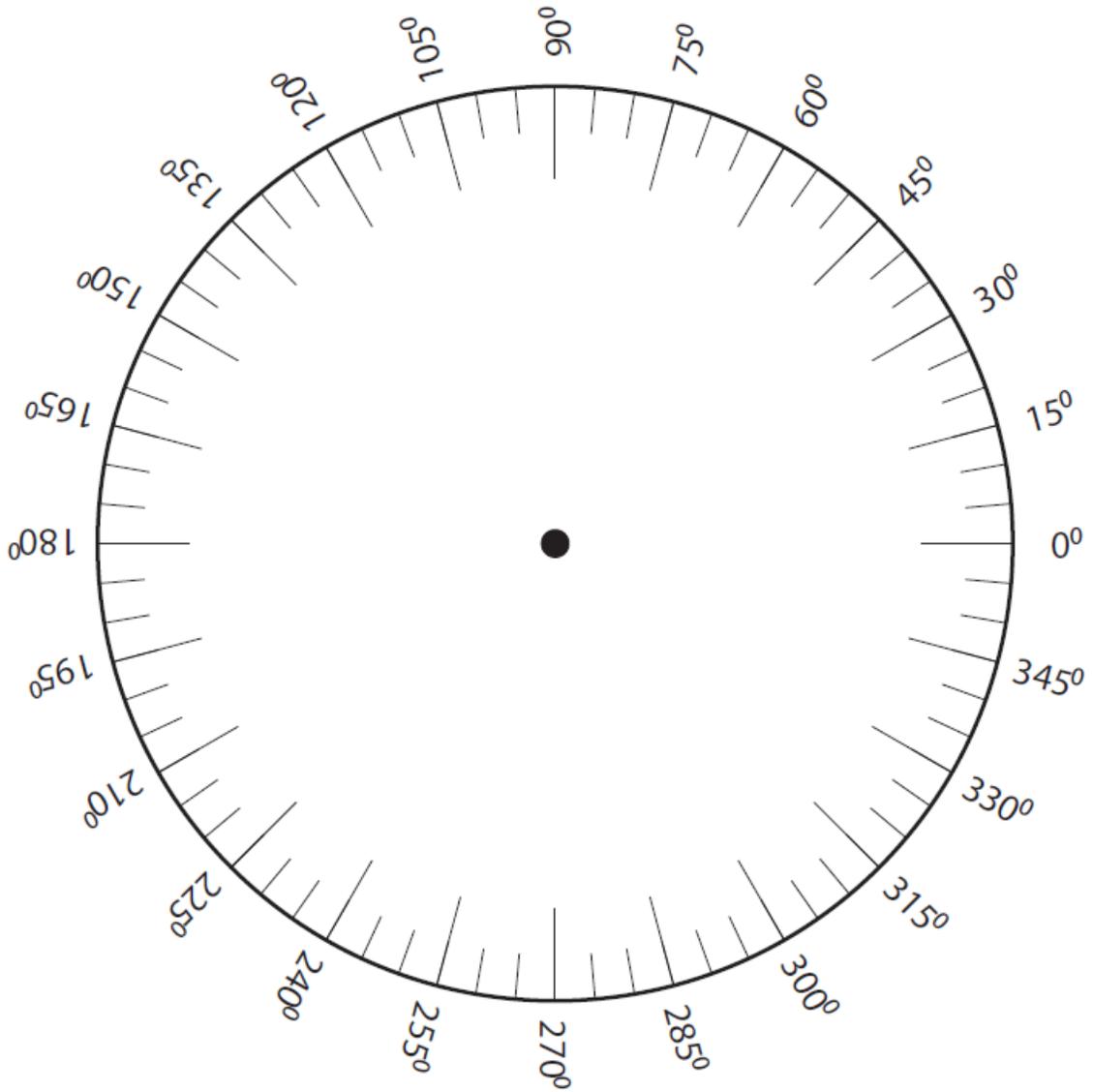
Case I
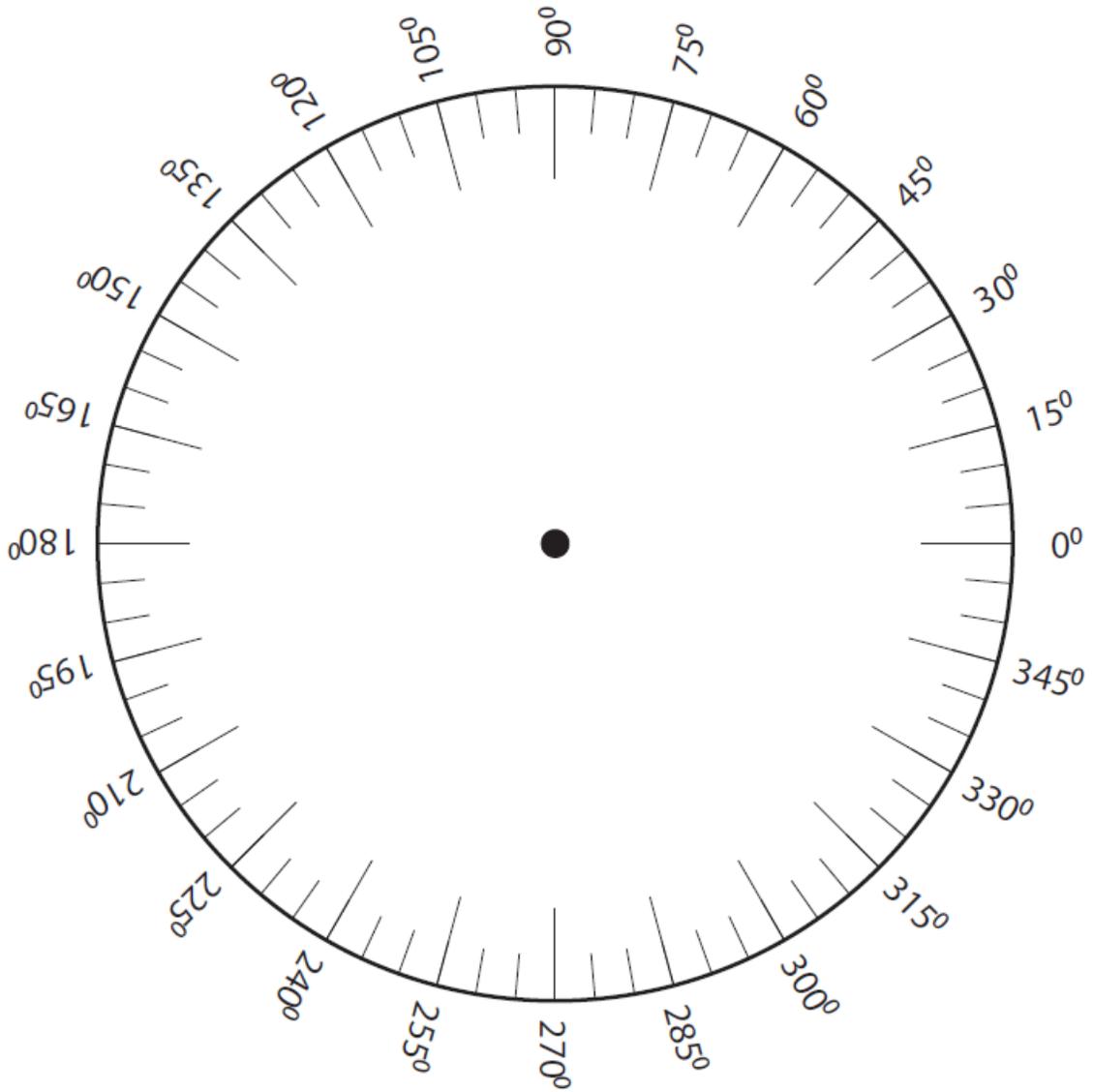
$$\vec{F_A} + \vec{F_B} + \vec{F_C} = 0$$

Vector	Mass (kg)	Magnitude (N)	Direction (°)	x-component (N)	y-component (N)
$\vec{F_A}$	0.200		30		
$\vec{F_B}$	0.200		120		
$\vec{F_C}$					

Case II

$$\vec{F_A} + \vec{F_B} + \vec{F_C} = 0$$

Vector	Mass (kg)	Magnitude (N)	Direction (º)	x-component (N)	y-component (N)
$\vec{F_A}$	0.200		20		
$\vec{F_B}$	0.150		80		
$\vec{F_C}$					

Case III
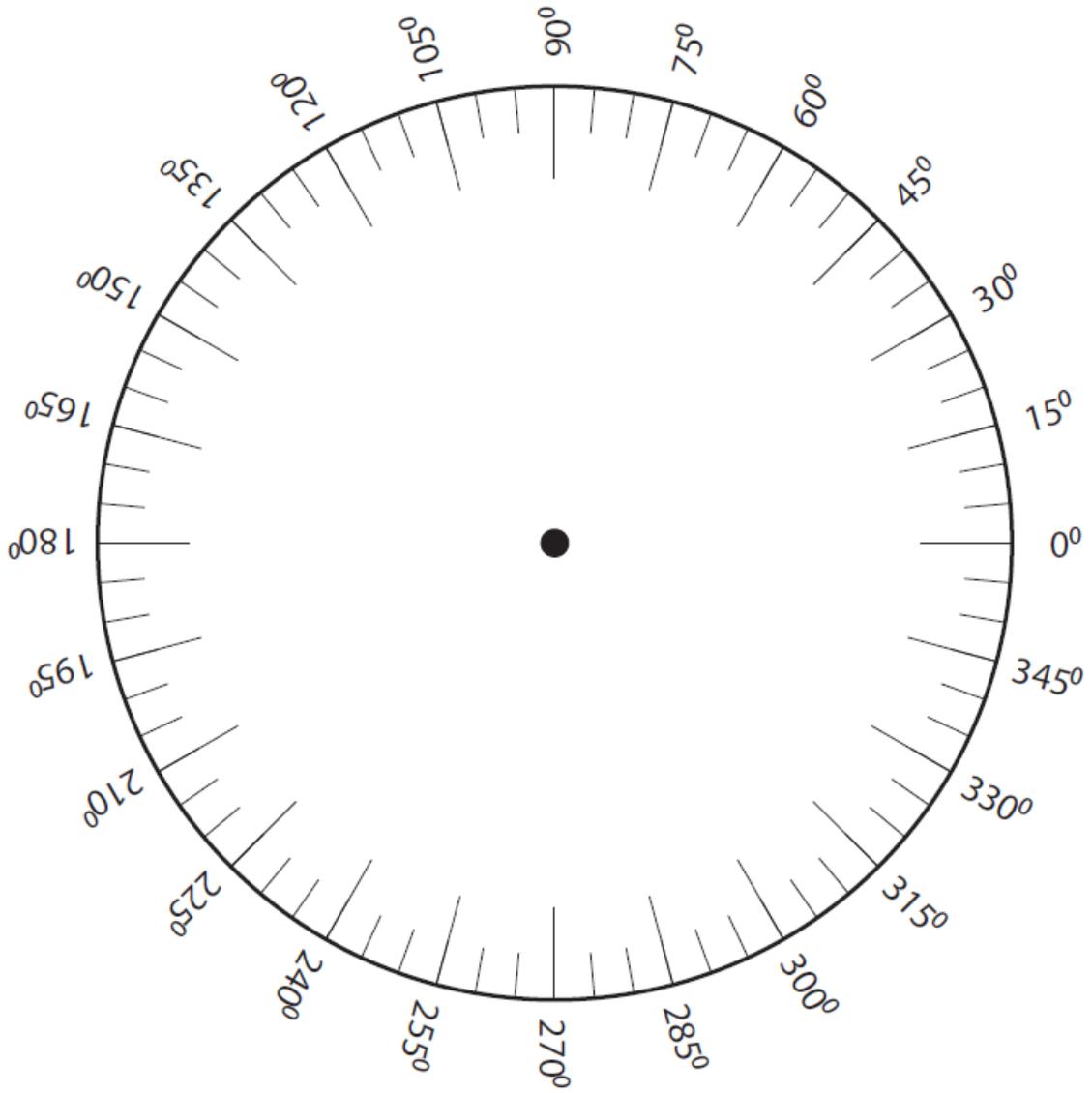
$$\overrightarrow{F_A} + \overrightarrow{F_B} + \overrightarrow{F_C} = 0$$

Vector	Mass (kg)	Magnitude (N)	Direction (°)	x-component (N)	y-component (N)
$\overrightarrow{F_A}$	0.200		0		
$\overrightarrow{F_B}$	0.150		90		
$\overrightarrow{F_C}$					

Case IV
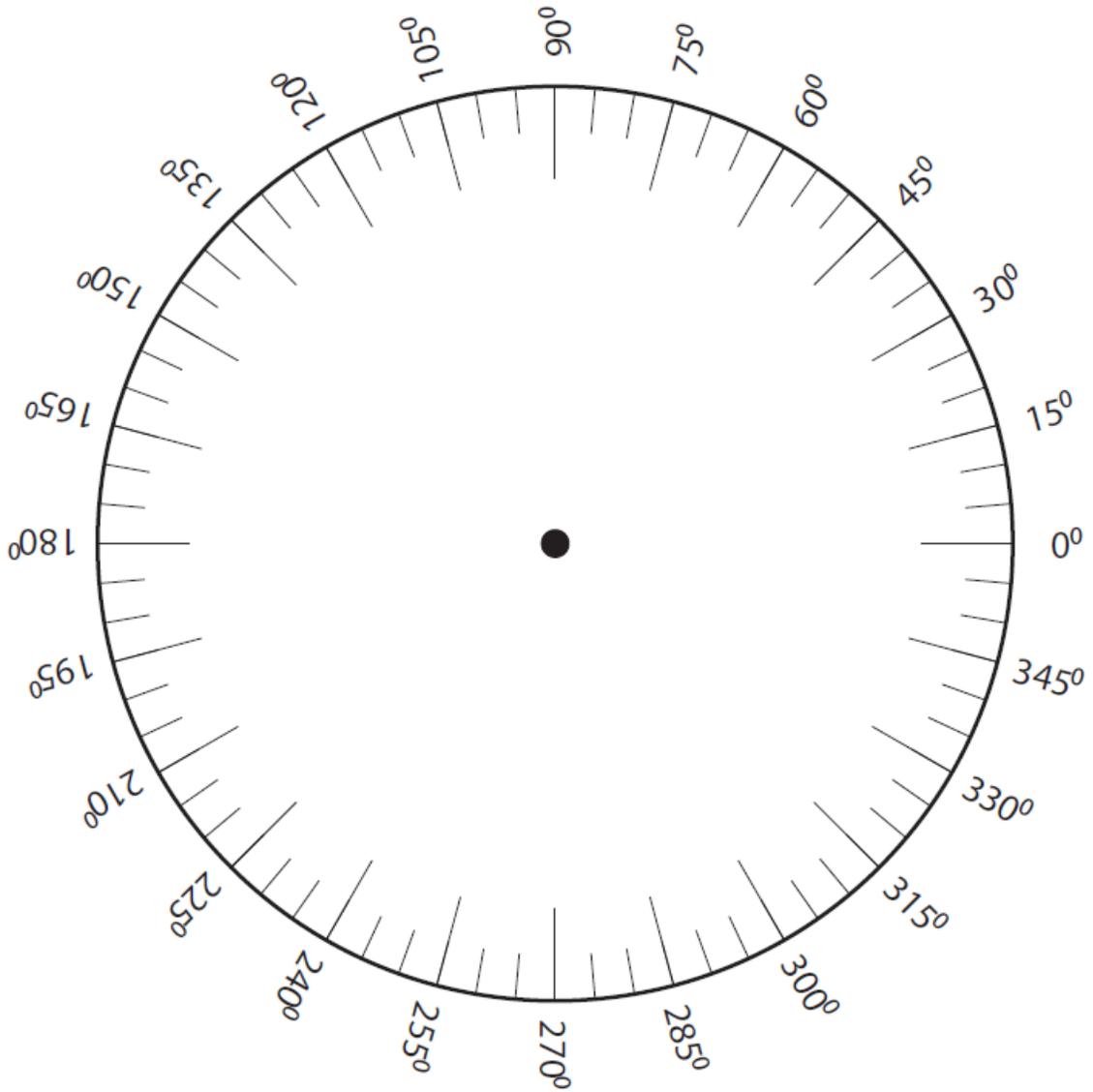
$\overrightarrow{F_A} + \overrightarrow{F_B} + \overrightarrow{F_C} = 0$

Vector	Mass (kg)	Magnitude (N)	Direction (°)	x-component (N)	y-component (N)
$\overrightarrow{F_A}$			0		
$\overrightarrow{F_B}$			90		
$\overrightarrow{F_C}$	0.300		240		

Case V
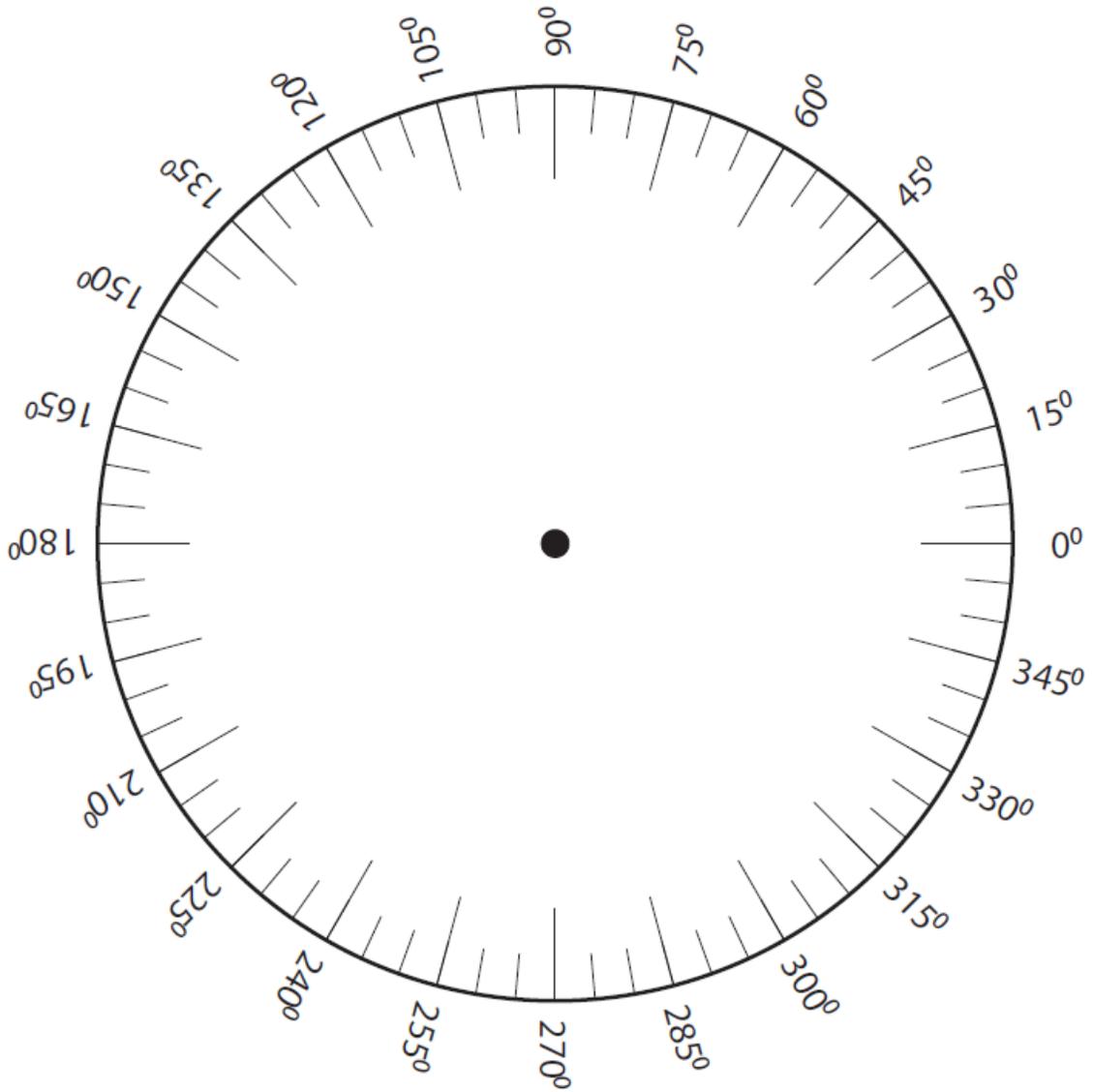
$$\vec{F_A} + \vec{F_B} + \vec{F_C} + \vec{F_D} = 0$$

Vector	Mass (kg)	Magnitude (N)	Direction (°)	x-component (N)	y-component (N)
$\vec{F_A}$	0.100		30		
$\vec{F_B}$	0.200		90		
$\vec{F_C}$	0.300		225		
$\vec{F_D}$					