Study Guide: Test 2 – Mechanical Equilibrium

The following is an overview of the concepts, ideas, and problems we have covered in this unit. You are, however, responsible for all material covered, regardless if found here or not. Therefore, be sure to review all your notes, worksheets, assignments, handouts, readings, labs, problems, etc…. It is suggested that you complete this study guide several days in advance so that you have time to seek extra help from your teacher or study group plus it will give you time to memorize the necessary information. You will be allowed a half-sheet of paper note card on this test upon which you may write whatever you desire (front and back). On the day of the test you will want to be well acquainted with the following material. Arrive prepared!!

Chapter 2.1	
Read pages 12 – 15 and know the following vocabulary terms listed there:	
• Force • Tension • Vector • Scalar quantity	• Net Force • Weight • Vector Quantity

Chapter 2.2	
Read page 16 and know the following vocabulary terms listed there:	
• Mechanical Equilibrium	• Equilibrium Rule

Chapter 2.3	
Read page 17 and know the following vocabulary terms listed there:	
• Support Force	•

Chapter 2.4	
Read pages 18-19 and know the following vocabulary terms listed there:	
• Friction • Static Equilibrium	• Dynamic Equilibrium

Chapter 2.5	
Read pages 19-22 and know the following vocabulary terms listed there:	
• Resultant	• Parallelogram Rule

The following equations will be given on the test (be sure you know how and when to use them and what each of the variables stands for!):

Given Equations and Values			
For a system in equilibrium, $\Sigma F = 0$ thus $F_{net} = 0$	$F_{net} = F_1 + F_2 + F\ldots$	$a^2 + b^2 = c^2$	SOH CAH TOA

(You will need to know how to complete algebraic manipulations on each of the above equations to solve for each of the variables in them)

Concepts

Force

1. What is physics the study of (4 things)?
2. Since physics underlies the other sciences, what is it sometimes referred to as?
3. What is a force? If we choose to give a force a negative value, say – 8 N, what does the negative sign mean?
4. What is the SI unit for force and how is it abbreviated?
5. Know the different common forms of force:
    a. What is an "applied force"? How is it symbolized?
    b. What is "gravitational force"? What is another name for it? What is a convenient way to determine its magnitude if you know an object's mass? How is it symbolized? What SI derived unit is it measured in?
    c. What is a "support force"? What is another name for it? What is it the result of? How is it symbolized?
    d. What is "tension"? What is it a result of? How is it symbolized?
    e. What is "frictional force"? What is it called when caused by plowing through air? How is it symbolized?

6. Know how to determine the direction of the common forms of force:
    a. You push a box to the right across the carpet. What is the direction of the:
        i. Applied force?
        ii. Frictional force from the carpet on the box?
        iii. Gravitational force of the Earth on the box?
        iv. Support force of the Earth on the box?
7. When more than one force acts on an object at once (a very common occurrence) what are you determining when you calculate "net force"? How is net force abbreviated? What is the general equation for net force?
8. What are vector quantities? What are scalar quantities? Give examples of each. Why is it important to distinguish between the two?
9. What does the word "magnitude" mean?
10. How can vectors be illustrated? What does the length of the arrow tell you about the vector quantity? What does the point of the arrow tell you about the vector quantity?
11. What is a "free body diagram"? What is each individual vector called? What is the final vector that represents the sum of all the individual vectors called? How do you properly place the vector arrows on a free-body diagram (arrow nose on center of box or arrow tail on center of box)?
12. How do you calculate with parallel vectors that act in the same direction? Opposite directions?
13. What is it called when vectors oppose and are not equal? What is it called in the special case when the vectors oppose and are equal? What is the net force in these instances?

Mechanical Equilibrium

14. What is the "law of entropy"? What does the law say about unstable things? For physical objects, stability can be achieved by becoming what?
15. What is "equilibrium"? What is another word for equilibrium?
16. What do the symbols ">", "<", "Σ", "≠" and "Δ" mean?
17. How can you tell if an object or system is in mechanical equilibrium? How can you tell if an object is not in mechanical equilibrium? What does it take to remove an object from its equilibrium state?
18. What do you know mathematically when an object is in mechanical equilibrium (what is the mechanical equilibrium equation and what does it mean)?
19. What are the two types of equilibrium and what differs between them?
20. Are all still objects in mechanical equilibrium? Are all moving objects in mechanical equilibrium? Can an object with only one force acting on it be in mechanical equilibrium?
21. What is a system?
22. Be able to solve a math problem (including mechanical equilibrium problems) **as taught in class** by first reading and understanding the problem (underlining the important information in the problem and drawing a picture if necessary), planning and solving (picking the right equation, solving the equation for the unknown you are looking for, listing the variables, and solving), and looking back and checking (estimate the answer and checking your answer against that estimation).

Non-Parallel Vectors

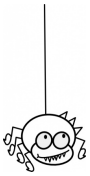
23. What is the difference between **graphical** vector calculation and **analytic** vector calculation?
24. Be able to apply the parallelogram rule along with an accurate graphical drawing, protractor, cm ruler, and scale to solve for the magnitude and direction of the resultant of two non-parallel vectors.
25. What does it mean to resolve a vector? Be able to accurately resolve an angled resultant into a pair of perpendicular (vertical and horizontal) components graphically. Be able to determine their magnitudes as well with cm ruler and scale.
26. Be able to use the Pythagorean theorem in the special case of vectors working perpendicular to find the magnitude of the resultant. Be able to apply basic trigonometry to solve for the angled direction of the resultant, as well as be able to correctly communicate the angle as acting in some combination of cardinal directions (ie., 30° N of E)
27. Be able to apply basic trigonometry to determine the resultant magnitude and direction for two components that are neither parallel nor perpendicular.
28. Why does a shirt hung on a rope strung tightly cause so much more tension than the same shirt hung on a slack, sagging rope? Be able to draw a free-body diagram that supports your answer.

Problems

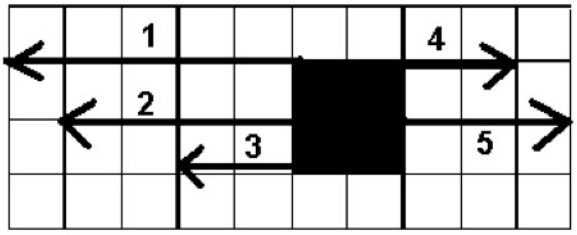
Show all work!

1. Draw free body diagrams, including vector arrows of proper relative length, proper direction, and properly labeled (F_{sup}, $F_{app.}$ etc…) to the right of each of the following pictured scenarios:



2. For the figure below showing parallel vectors, what is the net force acting on the object if (1 box = 1N):
   a. Only forces 1 and 4 are at work?
   b. Only forces 3 and 4 are at work?
   c. Only forces 1, 2, and 3 are at work?
   d. If all forces are at work?
   e. Which two forces would be at work if you wanted to give an example of balanced forces?
   f. Which combination of forces would result in no change in motion?
   g. Which combination of forces results in mechanical equilibrium?



3. A sofa is pushed with a force of 1000 N and moves at a constant speed in a straight line across the floor. What is the friction force between the floor and the sofa?

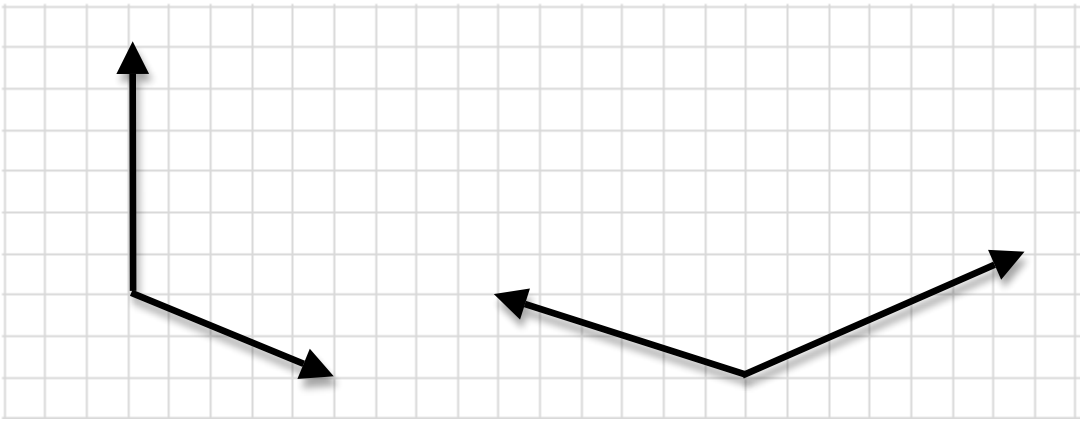
4. You carry a 200 N box across the room, holding it in both arms.
   a. How much force must be exerted by each arm to support the box?
   b. How will this force change if you hold the box with only one arm?

5. In the "Mechanical Equilibrium" lab, you place a 10 N weight on the 25 cm mark. What do the two scales read?

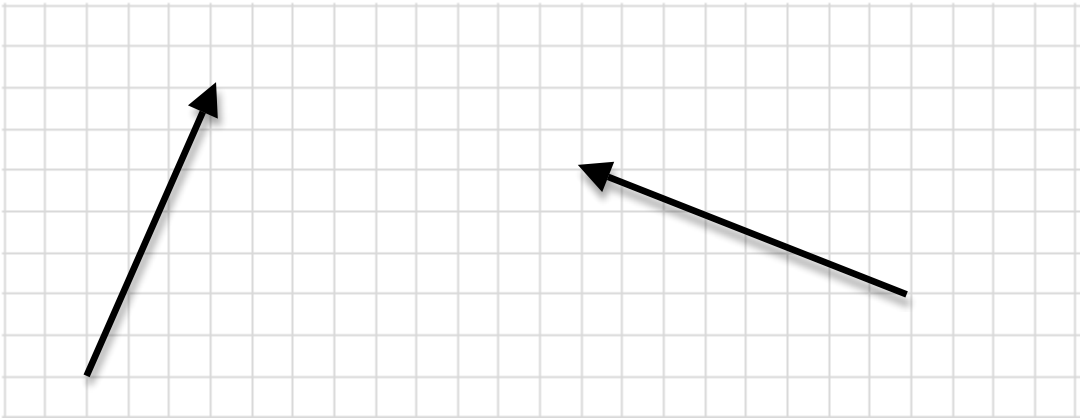
6. Five vertical ropes hold up a billboard that weighs 2000 N. What is the tension in each rope?

7. Steve and Doug are painting on a scaffold held by two ropes supporting the scaffold at its ends. Steve weighs 800 N and Doug weighs 1200 N. The tension in the left supporting rope is 1000 N. If the weight of the scaffold is 500 N, what is the tension in the right supporting rope? Show your work as taught in class for credit. Box your answer.

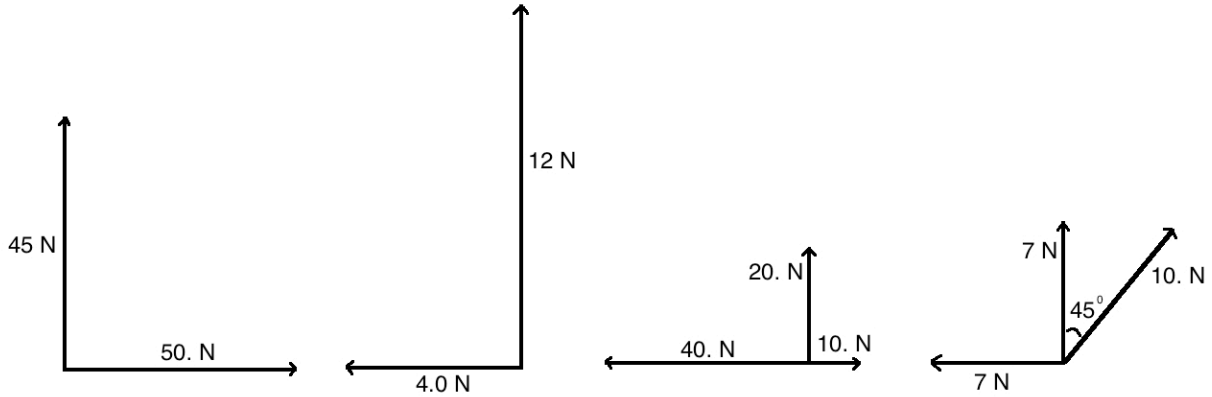
8. Using the parallelogram rule, draw the resultant (R) for each pairs of components shown below. From your drawing, find the magnitude and direction of the resultant (____ N, ____° ____ of _____)



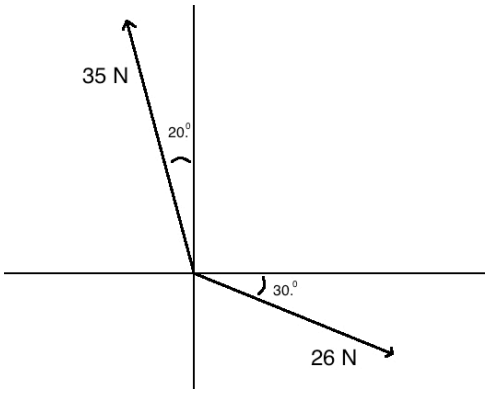
9. Resolve the following angled vectors into their vertical (y) and horizontal (x) components. From your drawing, find the magnitude of the components.



10. Using the scale of 1 cm = 1 N, determine the magnitude and direction of the resultants for the perpendicular vectors shown below. (Correctly state direction as ____ N, ____° ____ of _____)

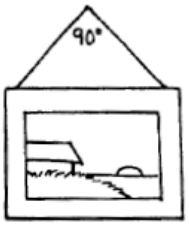


11. Using the scale of 1 cm = 1 N, determine the magnitude and direction of the resultant for the pair of components shown below. (Correctly state direction as ____ N, ____° ____ of _____)



12. In the "Weight of a Sign" lab, you read the tension in the rope to be about 10.00 N. The angle between the boom and the rope is 35°. Predict the magnitude of both the vertical ($F_{T\,y}$) and horizontal ($F_{T\,x}$) components of tension.

13. At an art auction, Whitney has acquired a painting that now hangs from a nail on her wall. If the painting weighs 100 N, what is the tension in each side of the wire supporting the painting?



14. As Nellie hangs from the rope below, which side is more likely to break first (or even odds)? Support your answer by drawing in the necessary vectors on the picture.