PHY 303K - Midterm 2 Practice Problems

1) While training for breeding season, a 380 gram male squirrel does 32 pushups in a minute, displacing its center of mass by a distance of 8.5 cm for each pushup. Determine the total work done on the squirrel while moving upward (32 times).

2) What is the center of mass of the object below? Mass is equally distributed throughout.

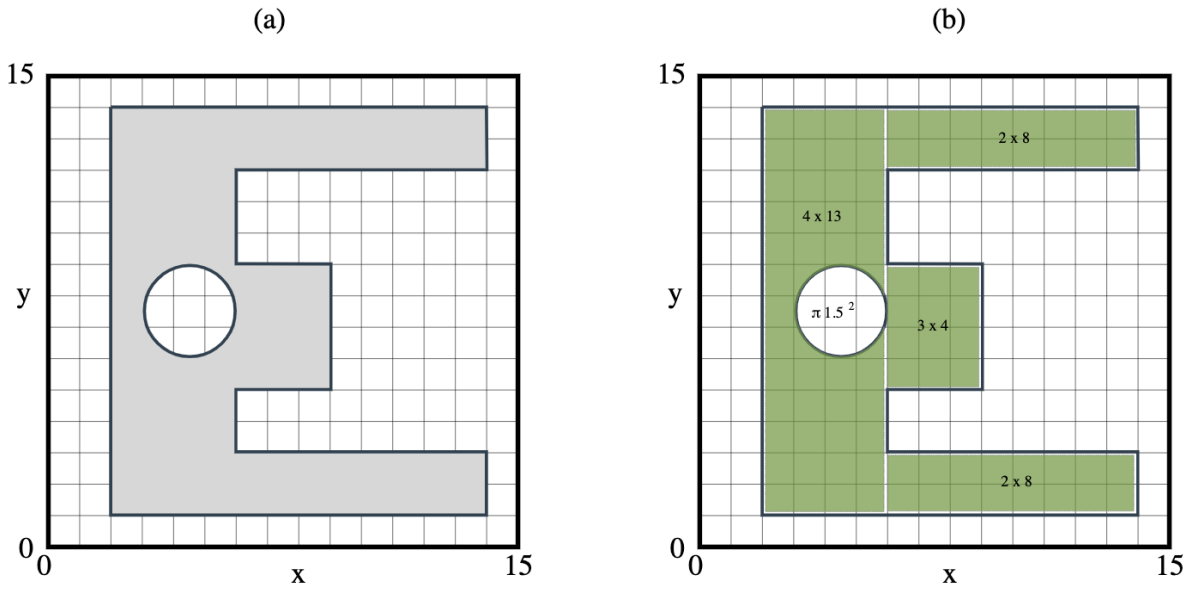


Figure 3: *(a)* An irregularly shaped flat object. *(b)* Object divided into simple shapes.

3) A 1000kg truck is towing a 500kg car up a 30° hill. The tow rope attached to the car however, is only able to withstand 3000 N of force before it breaks. Assuming the truck is parked, and the car is simply held in equilibrium on the hill without brakes on, how much more weight could be added to the car before the rope fails? (Use 10 m/s2 for the gravitational constant)

4) A cat of mass 5kg jumps on a dining table of mass 30kg. As the cat walks around on the table, what is the average force that the table applies to the cat?

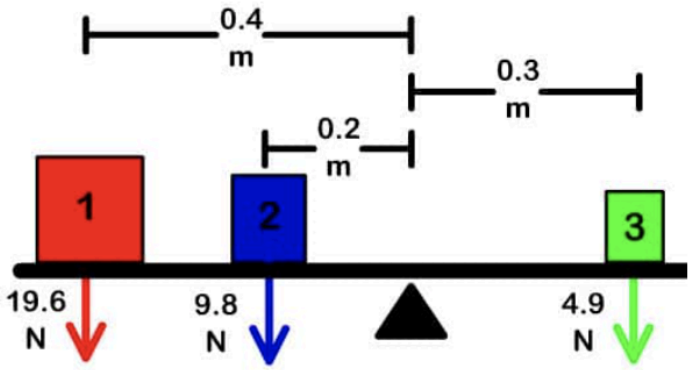
5) While driving down the road, a firefly strikes the windshield of a bus and makes a quite obvious mess in front of the face of the driver. This is a clear case of Newton's third law of motion. The firefly hit the bus and the bus hits the firefly. Which of the two forces is greater: the force on the firefly or the force on the bus?

6) Newton's first law states, "Every object remains at rest or in motion in a straight line at constant speed unless acted on by an unbalanced force." Is this "law" true in all reference frames? Explain.

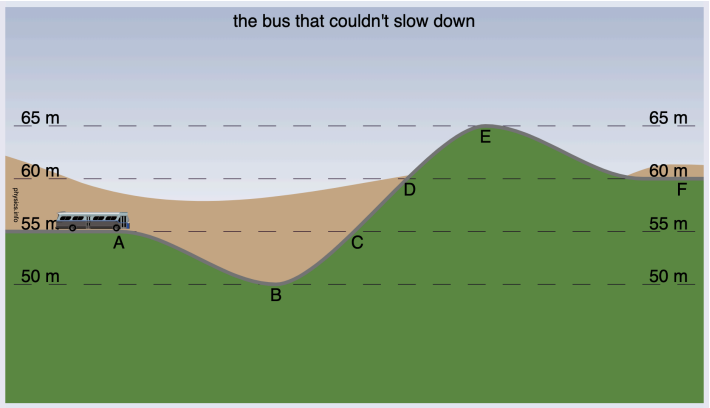
7) If you were allowed to leave your tray down while your DC-9 accelerates for takeoff, why would objects slide off the tray?

8) A 4.5-kg bucket in a well is being accelerated upward at a rate of 0.3 m/s/s as a result of an upward force of tension from a rope tied to the bucket's handle. How much tension is acting on the rope?

9) What is the sum of all torques in the system below?



10) The diagram below shows a 10,000 kg bus traveling on a straight road which rises and falls. The horizontal dimension has been foreshortened. The speed of the bus at point A is 26.82 m/s (60 mph). The engine has been disengaged and the bus is coasting. Friction and air resistance are assumed negligible. The numbers on the left show the altitude above sea level in meters. The letters A–F correspond to points on the road at these altitudes. Fill in the table below, noting that the potential energy at the lowest point, B, is 0 MJ.



	A	B	C	D	E	F
speed	26.82 m/s					
height	55 m	50 m	55 m	60 m	65 m	60 m
kinetic energy						
potential energy		0.000 MJ				
total energy						

Solutions

1) https://www.physicsclassroom.com/calcpad/energy/prob5.cfm
2) Source:https://www.khanacademy.org/science/physics/linear-momentum/center-of-mass/a/what-is-center-of-mass

We can break this object up into four rectangles and one circle as shown in figure 3b. Here we are only interested in the position of the center of mass in the relative units shown in the figure. The material has uniform density so the mass is proportional to the area. For simplicity we can represent the mass of each section in units of 'squares' as shown in the diagram.

In the x direction, the center of mass is at:

$$\frac{16 \cdot 10 + 52 \cdot 4 + 12 \cdot 7.5 + 16 \cdot 10 + (-7.1) \cdot 4.5}{16 + 52 + 12 + 16 - 7.1} = 6.6$$

Note that the area of the circular void is $\pi \cdot 1.5^2 \simeq 7.1$. This is accounted for as a negative mass.

In the y direction:

$$\frac{16 \cdot 13 + 52 \cdot 7.5 + 12 \cdot 7.0 + 16 \cdot 2 + (-7.1) \cdot 7.5}{16 + 52 + 12 + 16 - 7.1} = 7.4$$

3) Source:https://www.khanacademy.org/test-prep/mcat/physical-processes/x04f6bc56:vector-analysis-and-applications/e/force-of-tension-questions

1 / 4 The tension in the tow rope is dependent only upon the weight of the lighter car. Therefore the force due to gravity would be 5,000N.

2 / 4 On an inclined surface, the tension in the rope would be equal to the sinθ times the force vector hypotenuse, so in this case, we have a θ=30° and the vector of force would be our force due to gravity of 5,000N.

3 / 4 Our equation then would be 5,000 sin30= T, where T is the tension in the rope. Sin30 is ½, therefore T is 2,500.

4 / 4 **If T is 2,500 then the rope can withstand 500N more force. Since tension in this example will be equal to ½ mg due to sin30 =½ , and our T must be 500, we can use this formula solve for m.**

$$T = 1/2mg$$
$$500N = ½m\ x\ 10m/s^2$$
$$m = 100kg$$

4) This question is testing your understanding of Newton's third law (equal and opposite forces). The forces between the cat and table depend solely on the mass of the cat; therefore, the mass of the table is irrelevant.

   The force that the cat applies to the table is simply its weight. According to Newton's third law, the table also applies a force to the cat of the same magnitude. The force on the cat from the table is: $F_g = F_N = ma = (5\ kg)(9.8\ m/s\text{^}2) = 50\ N$

   Source:https://www.varsitytutors.com/ap_physics_1-help/newton-s-third-law

5) Trick Question! Each force is the same size. For every action, there is an equal ... (equal!). The fact that the firefly splatters only means that with its smaller mass, it is less able to withstand the larger acceleration resulting from the interaction. Besides, fireflies have guts and bug guts have a tendency to be splatterable. Windshields don't have guts. There you have it.

   Source: https://www.physicsclassroom.com/class/newtlaws/lesson-4/newton-s-third-law

6) https://www.vaia.com/en-us/textbooks/physics/physics-a-conceptual-world-view-7-edition/chapter-9/problem-1-newtons-first-law-states-every-object-remains-at-r/
7) https://www.vaia.com/en-us/textbooks/physics/physics-a-conceptual-world-view-7-edition/chapter-9/problem-31-if-you-were-allowed-to-leave-your-tray-down-while/
8)

Step 1: Draw a free-body diagram of the accelerating system.

We will first draw a diagram showing the forces acting on the bucket:

Notice that the weight of the bucket is less than tension because tension is greater than the weight, causing upward acceleration.

Step 2: Write an expression for the sum of all forces in the vertical direction, setting this sum equal to the mass of the accelerating object times the rate of acceleration.

We can write an equation for the sum of all the forces, subtracting the downward force of gravity from the upward force of friction and setting this equal to mass times acceleration as indicated by Newton's second law:

$$F_T - F_g = ma$$

Step 3: Symbolically solve the force equation for tension.

We can symbolically solve this equation in terms of known quantities. First, we will add the term for weight to both sides of the equation, canceling this from the left side:

$$F_T = ma + F_g$$

Next, we will substitute the weight term for mg, as this puts weight in terms of quantities whose values are known:

$$F_T = ma + mg$$

We can factor the mass out of the two right-side terms:

$$F_T = m(a + g)$$

The equation is now solved symbolically for tension.

Step 4: Substitute known variables into the equation to solve for the value of tension.

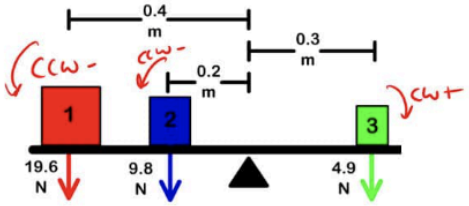
Finally, we will substitute the known quantities into the equation:

$$F_T = (4.5\ \text{kg})(0.3\ \text{m/s}^2 + 9.8\ \text{m/s}^2) \approx 45\ \text{N}$$

The force of tension in the rope is 45 Newtons.

Source:
https://study.com/skill/learn/calculating-vertical-tension-forces-on-an-accelerating-object-explanation.html

9) Take each individual torque making the clockwise positive and counterclockwise negative. Then add all the numbers together and get a sum. Since the final answer was negative 8.33 Nm the direction will be counterclockwise.



$$\sum \tau = F_1 d_1 + F_2 d_2 + F_3 d_3$$
$$= \overset{ccw}{-}(19.6)(0.4) - (9.8)(0.2) + \overset{cw}{(4.9)}(0.3)$$
$$= -7.84 - 1.96 + 1.47 = -8.33\ \text{N·m}$$
$$\overset{ccw}{\uparrow}$$
8.33 N·m ccw

Source:
https://stickmanphysics.com/stickman-physics-home/universal-gravitation-and-circular-motion/torque/torque-example-solutions/

10) https://physics.info/energy-conservation/practice.shtml