Mass – Part IV

Motion and Mass

End of Module Questions:

1. In ancient Mediterranean cultures, coins were made out of pure metal and the value of a coin was determined by the mass of the metal used to make the coin. Once upon a time, three merchants from different cultures met to buy and sell goods. Merchant #1 had a pocket full of Nara coins, Merchant #2 had a pocket full of Filsa coins, and Merchant #3 had a pocketful of Mac coins. The first thing they needed to do was figure out how many Nara in a Filsa, how many Filsa in a Mac, and so on.

a) Explain in words (and pictures if you like) how the three merchants could have determined the relative values of their coins using only a few sticks, some cloth, and some string.

A method would be to hang the cloth from a stick and create a balance. The cloth pockets would need to be placed so that the stick was level.

b) It turns out that four Filsas have the same mass as one Mac. Three Macs have the same mass as two Naras.

i) How many Filsa would have the same value as 1 Nara? (Show your work)

It helps to write out that:

4 Filsa = 1 Mac

3 Mac = 2 Nara

The unit that is common is the Mac so we need to convert the other units into Macs.

1 Mac = 2/3 Nara

Therefore, 4 Filsa = 2/3 Nara

Or 6 Filsa = 1 Nara

ii) Hoping that Merchant #3 didn't pass IDS 101, Merchant #2 decides to try and fool her. He quickly demonstrates that he can balance one Mac with one Filsa. How did he do it and where did he have to hang the two coins to pull off his trick?

Since 4 Filsa = 1 Mac, then the merchant would move the Mac (which is four times denser) to a position on the stick that is 1/4 of the distance of the Filsa.
2. The following questions all refer to a set of experiments with the balance shown below. A meter stick is balanced on a pivot point. Four pieces of aluminum metal are then placed 22 cm from the balance point. Each piece of aluminum has dimensions of 1 cm x 1 cm by 1 cm.

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22 cm

a. If you remove just one of the four pieces of aluminum, where will you have to place it on the other side to balance the remaining three pieces? Show your work or explain your reasoning.

Moving one of the pieces of aluminum will leave three pieces on the left side, therefore the turning effect on the left will be 3 alum pieces times 22 cm = 66 alum pieces-cm. To balance the rod, we must place the one aluminum piece 66 cm to the right of the center point.

b. Next you are going to try balancing all four pieces of aluminum (in the original position shown in the diagram) with one piece of lead.

Since the pieces of lead are the same volume as the aluminum, one piece of lead would equal the same mass as all four pieces of aluminum. This means that the lead should be placed 22 cm to the right of the fulcrum.

If you use three of pieces of lead, where will they need to be placed in order to balance the four pieces of aluminum (in their original position)? Show your work or explain your reasoning.

Depending on how you read the question, there could be more than one answer, but here is one approach. The turning effect on the left must equal the turning effect on the right. We know that each piece of lead is equal to 4 aluminum pieces, so we can say that:

\[(22 \text{ cm}) (4 \text{ aluminum blocks}) = (X)(12 \text{ aluminum blocks})\]

\[X=7.3 \text{ cm to the right of the fulcrum.}\]
Finally, imagine repeating the experiment with a 2 cm x 2 cm x 2 cm piece of lead.

![Image of a 2 cm x 2 cm x 2 cm piece of lead]

Where should this piece of lead be placed in order to balance the four pieces of aluminum? Show your work or explain your reasoning.

*The larger block of lead would be 8 cm$^3$ in volume which would equal 32 aluminum blocks. Using the same turning effect equation above the lead would be placed at 2.75 cm to the right of the fulcrum.*

3. Consider the lever shown below. If there are no weights on the lever it will be perfectly balanced on the fulcrum shown in the center.

![Image of a lever]

a) Block B has the same width and thickness as block A, but block B is twice as tall. The lever balances when blocks A and B are the same distance from the center. How does the density of block B compare to the density of block A? (Be quantitative and explain your reasoning.)

*If the distances from the center are the same and the board is balanced, the masses of the two blocks must be the same. If block B has twice as much volume, the density of block B must be 1/2 that of block A.*

b) The two blocks labeled C in the diagram below have masses of 30 g each. The lever is balanced when one block C is 20 cm from the center and the other block C rests on block D 5 cm from the center. What is the mass of block D? (Be quantitative and explain your reasoning and/or show your work.)
\[(30 \text{ g})(20 \text{ cm}) = (30 \text{ g})(5 \text{ cm}) + (X)(5 \text{ cm})\]

\[X = 90 \text{ g}\]

c) Two identical 12 g blocks are placed on the lever, 20 cm and 25 cm from the center. Where would one have to place a single 60 g block to balance the lever? (Be quantitative and explain your reasoning and/or show your work)

\[(12 \text{ g})(25 \text{ cm}) + (12 \text{ g})(20 \text{ cm}) = (60 \text{ g})(X)\]

\[X = 9 \text{ cm}\]

4. a) Since the mass is the same and the engine pushing the drum, the drum would be moving a speed of 0.2 m/s in 5 seconds

b) Given in the problem, the hovercraft move the 20000 ton drum at 0.4 m/s in 10 seconds. Therefore the hovercraft will move the drum 0.1 m/s in 2.5 sec. In 15 sec (2.5 times 6) the hovercraft will move the drum at a speed of 0.6 m/sec.

c) The speed decreases, the same relationships between mass and change in speed apply. Therefore, to go from 10 m/s to 5 m/s is a change in speed of 5 m/s. At the rate of 0.1 m/s for 2.5 sec as noted in part b, the time would be 12.5 sec.

d) Since the mass of this drum is \(\frac{1}{2}\) as much as the original drum, the time needed to get to the same speed would be \(\frac{1}{2}\) of the time= 5 sec.

d) The rate of change in speed for the smaller drum would be \(\frac{1}{2}\) since it is \(\frac{1}{2}\) of the mass-- change in speed of 0.3 m/s= \(3.75\) sec

e) The drum changed speed twice as fast as the 20,000 ton drum, so the it must be a 10,000 ton drum.

f) This drum moves 0.1 m/s in 1 sec compared to the 20,000 ton drum which was 0.1 in 2.5 sec, therefore the mass of the unknown drum must be 8000 tons

5. a) less
b) same)
c) same
d) same)
e) less
f) same