Problems on Levers and Machines

Answers:

17 - 20 p100

17. The c.m. (center of mass) and the horizontal balance point for a meter stick are exactly the same point since the meter stick is made of a uniform material and it is a regularly shaped geometric figure.

18. a) The center of mass for a golf ball is at the exact center of the ball.
 b) The center of mass of a doughnut (with a hole in the middle) is in the middle of the doughnut -- where the hole is.

19. a) A box-shaped trailer carrying a load of grain will have a fixed center of mass in the middle of the grain.
 b) A box-shaped trailer carrying a load of pigs will have a center of mass in the middle of the box cart. But because the pigs may be moving from side to side it may shift slightly with their motion.
 c) A box-shaped trailer carrying a load of standing horse will have its center of mass above the middle of the box cart almost at the midsection of the average horse height.

20. a) The approximate center of mass of a golf club can be found by suspending the club by a thin rope or thread and marking the point at which it stays balanced.
 b) A framed painting is a regular geometric figure (a rectangular or square shape).
 Its center of mass can be found by tracing bisecting lines from each corner and
 marking the point where they intersect.
 c) The center of mass of a boomerang can be found by hanging masses on thin threads from different points on the boomerang, tracing the threads and marking the point where they intersect.

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21. Two features that provide greater stability for an object are:
a) the object must have a low center of mass
b) the object must have a wide base

22. The condition for stability is:
The center of mass must lie directly above the base of the object

23. If you trace a perpendicular line from the center of gravity of each object to its base you will see that object (b) is very stable. Also, object (d) is stable because its c.m. is very close to its base.

24. One could use a pen to illustrate
a) a very stable object by balancing the pen (without the cap) on a finger tip -- its c.m will be the middle of the pen.
b) If you try to balance the pen on its tip it will be very hard.

The pen in this position is an example of a very unstable object.
c) A pen with a cap on is much more difficult to balance than a pen without the cap on. This is an example of a medium stability object.

25. From most stable to least stable the filing cabinets shown in the picture are ranked as:
(d) most stable, (a) stable, (b) unstable, (c) very unstable

26. Your body shifts to maximize stability positions in different situations. For example:
a) When lifting a heavy object from a table top you would tend to lean forward.
b) When carrying a heavy load on one arm you tend to shift your body weight to the other side of the body.
c) When walking upstream through rapidly moving waters you tend to bend in the direction of current flow.

27. A tightrope walker uses a long pole which droops down at both ends to maximize his stability because such a pole (as opposed to a straight one) will give him better control over the shifting position of his center of mass as he balances it over the rope.

28. Two examples that illustrate the importance of center of mass are:
a) learning canoeing
b) learning how to ride a bicycle

Chapter Review:

1. The angle between the a rigid body and the applied force used in calculating torque is 90^o.

In the equation $\tau = F \text{ x } d$ (d is perpendicular to F).

2. Cars have smaller steering wheels than trucks because, using the same applied force from a drive, they need to provide a smaller torque than trucks.
(smaller circumference = smaller radius = smaller torque).

3. In the human body we have all three classes of lever in different bone-muscle systems.
a) The jaw is a first class lever
b) the foot is a second class lever
c) the elbow-forearm system is a third class lever

4. Given: F = 300 N, d = 1.2 m Find: τ Solution:

$$\tau = F \text{ x } d = 300 \text{ N x } 1.2 \text{ m} = 360 \text{ N.m}$$

5. Given: F = 20 N, d = 0.3 m Find: τ Solution:

$$\tau = F \text{ x } d = 20 \text{ N x } 0.3 \text{ m} = 6.0 \text{ N.m}$$

6. The law of the lever states that:

For an ideal lever: Total Torque In = Total Torque Out
Effort Torque = Load Torque
Effort Force x Effort distance = Load Force x Load distance

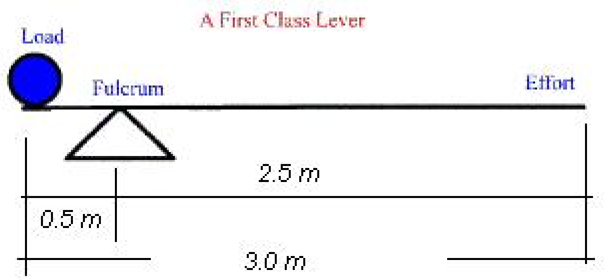
in mathematical symbols Fe x de = Fl x dl

7. Using the law of the lever: Fe x de = Fl x dl

i.e. Load Torque = 240 N x 3.5 m = 840 N.m
Effort Load = 180 N x 4.5 m = 810 N.m

As we can see, the Load Torque IS NOT equal to the Effort Load ∴ Lever IS NOT balanced.

8. a) diagram of a first class lever



b) Given: Fl = 600 N Find: Fe
dl = 0.5 m
de = 2.5 m

Solution: Fl x dl = Fe x de

∴ Fe = (Fl x dl) / de
= (600 N x 0.5 m)/2.5 m
= 120 N

∴ <u>Fe, The effort needed to lift the load = 120 N</u>

9. Given: Fl = 800 N Find: de
dl = 0.6 m
Fe = 320 N

Solution: Fl x dl = Fe x de

∴ de = (Fl x dl) / Fe
= (800 N x 0.6 m) / 320 N
= 1.5 m

∴ <u>de, The distance from the girl's hands to the fulcrum is 1.5 m</u>

10. Given: de = 4.0 cm = 0.04 m Find: Fl
dl = 30 cm = 0.30 m
Fe = 1500 N

Solution: **Fl x dl = Fe x de**

∴ Fl = (Fe x de) / dl
= (1500 N x 0.04 m)/0.3 m
= 200 N

∴ <u>The load that the boy's hand can support is 200 N</u>

11. a) Given: de = 1.5 m Find: dl
Fl = 1200 N
Fe = 400 N

Solution: **Fl x dl = Fe x de**

∴ dl = (Fe x de) / Fl
= (400 N x 1.5 m) / 1200 N
= 0.5 m

∴ <u>The distance between the load and the fulcrum is 0.5 m</u>

b) To find the mass of the load

Fg = m x g = Fl

∴ m = Fl / g = 1200 N / 9.8 N/Kg
= 122 Kg

12. a) To find the center of mass of a large wooden block cut in the shape of a capital "R" one would hold the R from three different point and trace a vertical line from each point toward the center of the earth. Where these lines intersect, that's where the center of mass of the block is found.

b) So that the block would hang straight, a hole would be drilled at the position of the center of mass.