

SSSS 2019-2020



Exploring the World of Science

Machines (Div B)

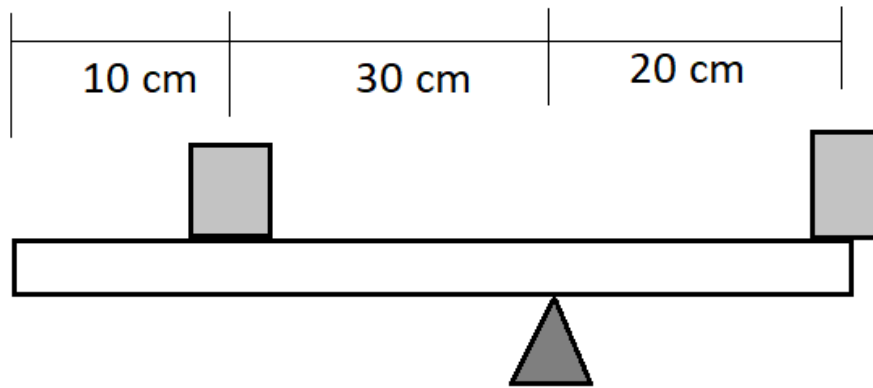
Key

Written by Unome

Instructions

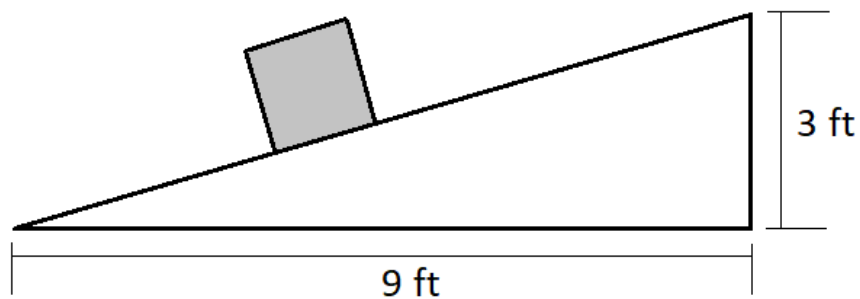
- 1) The space provided for each question is sufficient to fit a response earning full points.
- 2) Each question is worth 1 point. This test has a total of 30 points, normalized as according to the rules.
- 3) For calculation questions, answers within a reasonable range will earn full credit. Use 9.8 m/s^2 as the value of gravitational acceleration. If necessary, round to three significant figures. Assume the machine and other such objects are ideal unless otherwise specified.
- 4) Ties will be broken by comparing each question in order.

For questions 1-4, refer to the image below. The box on the left is 1 kg and the box on the right is 2.5 kg.



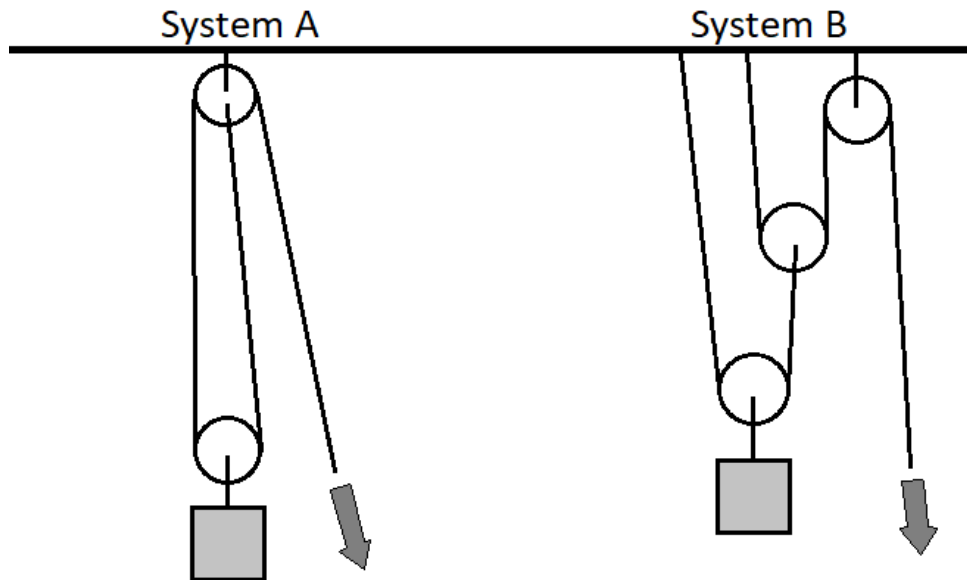
1. What class of lever is this? **Class 1**
2. This lever is not balanced. Which box (left or right) is producing more torque? **Right**
3. Suppose you place a box on the leftmost edge of the beam. How much torque must it produce to balance the lever? **1.96 N*m**
4. What is the mass of the box from the previous question? **0.5 kg**

For questions 5-9, refer to the image below.



5. What type of simple machine is this? **Inclined plane**
6. What is the IMA of this machine? **3**
7. Suppose the box is 15 kg. What is the minimum force that would hold it up? **49 N**
8. Suppose that in order to get the box moving up the ramp, you have to apply 60 N of force. What is the AMA of this machine? **2.45**
9. What is the efficiency of the machine as a percent? **81.7%**

For questions 10-15, refer to the image below. Each of the boxes has a mass of 20 kg.

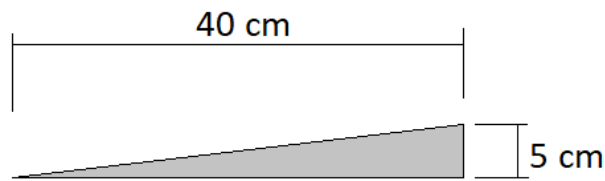


10. What is the IMA of System A? **2**
11. What is the IMA of System B? **4**
12. How much force is needed to balance System A? **98 N**
13. How much force is needed to balance System B? **49 N**
14. An IMA greater than 1 for a pulley implies that part of the load is being supported by something other than the person applying force to the end of the pulley. In the image above, what is ultimately supporting the rest of the load? **The ceiling**
15. Suppose you extended the chain of pulleys in System B by adding another pulley to the bottom and attaching the other side of the rope to the ceiling. What would be the IMA of this system? **8**

For questions 16-20, consider a person lifting 20 kg of dirt with a wheelbarrow. The dirt is balanced 0.75 meters away from the wheel, while the person lifting is applying force 1.5 meters away from the wheel. Assume the beam is close to horizontal.

16. What class of lever is this? **Class 2**
17. What is the IMA of this lever? **2**
18. If the lever is ideal, how much force is the person applying? **98 N**
19. We have seen that torque is balanced – however, forces must also be balanced in order to keep this beam in static equilibrium. What is providing the rest of the force? **The ground**
20. What is the value of the force from the previous question? **98 N**

For questions 21-23, consider a person swinging an axe into a tree. The axe is in the shape of a wedge, with a blade length of 40 cm and a maximum thickness of 5 cm at the handle end, as shown in the image below.



21. What is the IMA of the axe? **8**
22. If the axe blade is swung with a force of 250 N, how much force is applied to the tree? **2000 N**
23. Suppose, for some reason, that you placed the axe blade on the ground and used it as a ramp. What is the IMA of this ramp? **8.02**

For questions 24-26, consider a doorknob with a diameter of 4 cm. The rod has a diameter of 1.5 cm.

24. What type of simple machine is this? **Wheel and axle**
25. What is the IMA of this machine? **2.67**
26. If the door spring will only compress to the point of opening when 15 N of force is applied, how much torque must be applied to the knob to open the door? **0.225 N*m**

For questions 27-30, consider a gear system composed of several gears with the same tooth size. The drive gear has 20 teeth, and interlocks with a second gear with 10 teeth. The second gear is connected axially to a third gear with 30 teeth, which interlocks with a fourth output gear with 5 teeth.

27. What is the gear ratio between the drive gear and the second gear? **2**
28. What is the gear ratio of the entire system? **12**
29. If the drive gear is rotated at a rate of 100 rpm, how fast does the output gear rotate? **1200 rpm**
30. If the drive gear is rotated with 50 N, how much force does the output gear provide? **4.17 N**