Science Olympiad Division C Machines Test

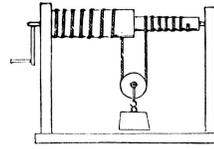Written by West Windsor-Plainsboro High School South

- There are 3 sections: Matching, Multiple Choice, and Free Response
- The test is worth 67 points in total
- Write all answers on the answer sheet
- Round values to 2 decimal places
- g = 9.8 m/s^2

Score: _____/67

Match the term/machine with the appropriate definition/image (11)
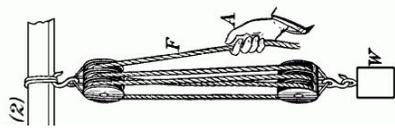
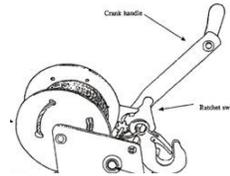1. Spur Gear

a.

2. AMA

b.

3. Block and Tackle

c.

4. Sheave

d.

5. Torque

e.

6. Winch

f.

7. Efficiency

g.

8. Worm Gear

h. The ratio of output work to input work

9. Sprocket

i. Rotational analogue of force

10. Windlass

j. The ratio of output force to input force

Multiple Choice (More than one answer choice may be correct for some questions) (12)

1. Which of the following are characteristics of ideal machines
    a. Input force is equal to output force
    b. Input work is equal to output work
    c. Input power is equal to output power
    d. Friction and elasticity can be ignored

2. A system has 3 movable pulleys and 2 anchored pulleys. What is its mechanical advantage?
    a. 4
    b. 5
    c. 6
    d. 10

3. How do you determine the mechanical advantage of a compound machine
    a. Add the mechanical advantages of the components
    b. Multiply the mechanical advantages of the components
    c. Divide the mechanical advantages of the components
    d. Subtract the mechanical advantages of the components
    e. None of the above

4. A doorknob can be classified as which of the following machines
    a. Lever
    b. Pully
    c. Wheel and Axle
    d. Wedge
    e. Screw

5. A meterstick is balanced on a fulcrum at the 50 cm mark. 3 identical masses are placed at the 10 cm, 30 cm, and 90 cm marks. Where should a fourth mass be placed in order to put the system in equilibrium?
    a. 80 cm
    b. 20 cm
    c. 70 cm
    d. 60 cm

6. The unit of torque is equivalent to which of the following
    a. Newton - meter

b. Newton
c. Joule
d. Watt

7. The IMA of a lever is defined as
    a. Effort arm/Load arm
    b. Load arm/Effort arm
    c. Load arm * Effort arm
    d. None of the above

8. The IMA of an inclined plane is defined as
    a. height/length
    b. hypotenuse/height
    c. length/height
    d. length/hypotenuse
    e. height/hypotenuse

9. The IMA of a wedge is defined as
    a. side length/(2*thickness)
    b. side length/thickness
    c. thickness/(2*side length)
    d. thickness/side length

10. The IMA of a wheel - axle system is defined as
    a. wheel radius/axle radius
    b. axle radius/wheel radius
    c. (wheel radius - axle radius)/wheel radius
    d. wheel radius/(wheel radius - axle radius)

11. The IMA of a gear is defined as
    a. radius of output gear/radius of input gear
    b. radius of input gear/radius of output gear
    c. number of teeth on input gear/number of teeth on output gear
    d. number of teeth on output gear/number of teeth on input gear
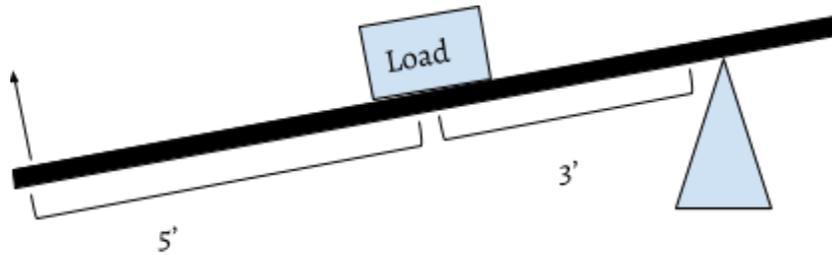
12. The IMA of a screw is defined as
    a. radius/pitch
    b. circumference/pitch
    c. pitch/radius

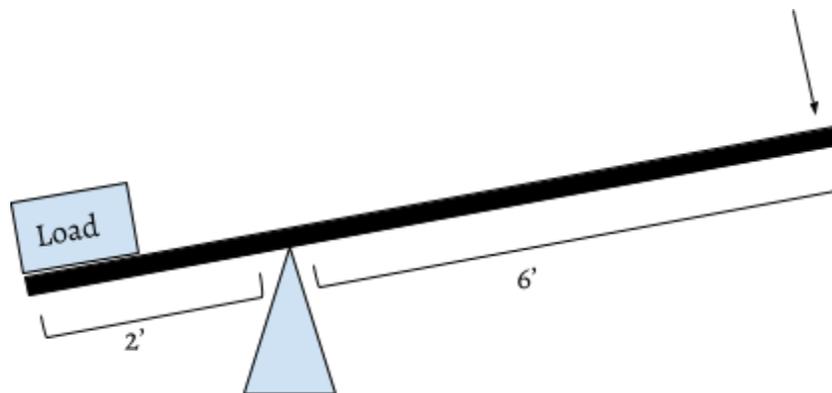   d. pitch/circumference

Free Response

1. Classify the three levers and find the mechanical advantage for each one. Then provide a real-life example for each class (9):
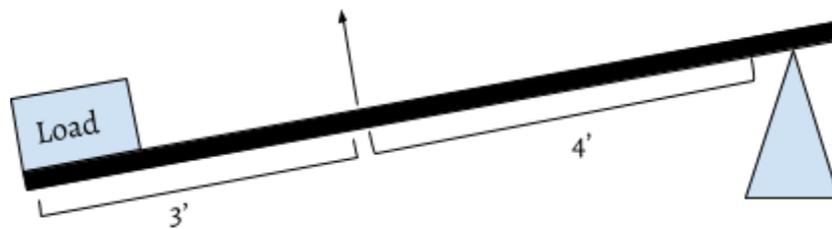
    a.

    b.

    c.

2. Given three classes of levers with the same length, which type of lever would have the greatest mechanical advantage and why? (2)

3. Arya uses a wheelbarrow that is 150 cm long to haul a 40 kg load which is located 20 cm away from to axle. Find:

        a. The mechanical advantage of the wheelbarrow (1)

b. The minimum effort force Arya must exert in order to use the wheelbarrow (1)

4. A winch has a 20 cm long handle that turns in a circle, rotating an axle of with a diameter of 8 cm. What force must be applied to the system to lift a mass of 50 kg? (2)

5. Determine the mechanical advantages of the following pulleys: (4)
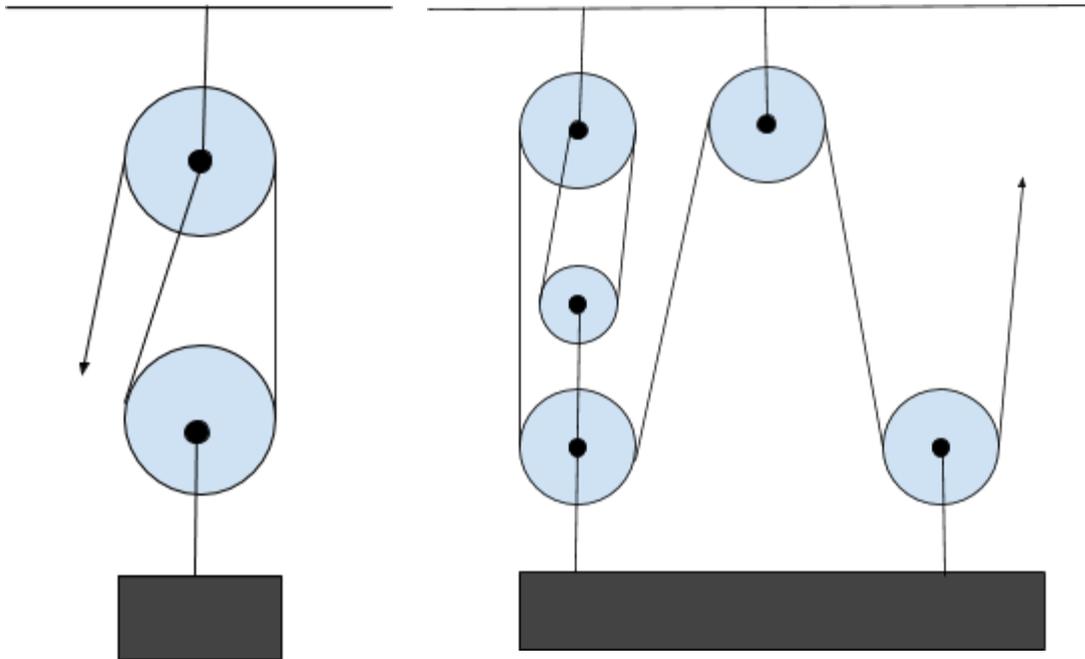

6. Bob, who weighs 700 N, is sitting on a (massless) chair which is attached to a pulley (see figure on the right). He begins to pull down on the rope, lifting him and the chair upwards at a constant velocity.

   a. How much force is Bob exerting on the rope (2)

   b. How much force is the pulley exerting on the ceiling (2)
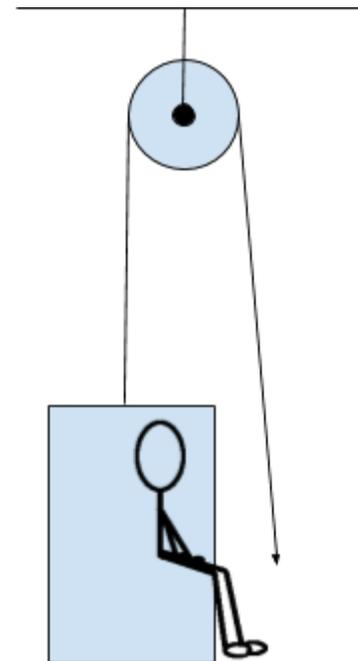
   c. If the pulley system shown in the diagram was changed to the pulley system shown to the left, what would be the new answers to questions a and b (4)
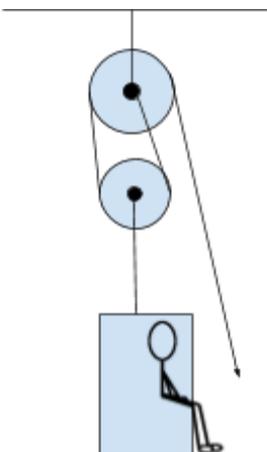
7. A block of mass 5kg is sliding up a 30-degree inclined plane with initial velocity 8 m/s. The block slides through a distance of 6m before momentarily stopping at the top of the ramp.

    a.   Determine the coefficient of kinetic friction between the block and the ramp (3)

    b. What is the ideal mechanical advantage of this inclined plane? (2)

8. A jackscrew has a pitch of 20 mm and a handle length of 15 cm

    a.   What is the ideal mechanical advantage of the screw? (1)

    b. What load could ideally be lifted with an input force of 30 N? (1)

    c.   What load could actually be lifted if the screw has an efficiency of 34%? (2)

9. If an effort force of 100 N is applied to the system shown below, what weight load can be moved up the ramp neglecting friction? (The winch has a crank radius of 0.25 m and an axle radius of 0.10 m; the inclined plane has height of 3 m and a hypotenuse length of 9 m) (5)
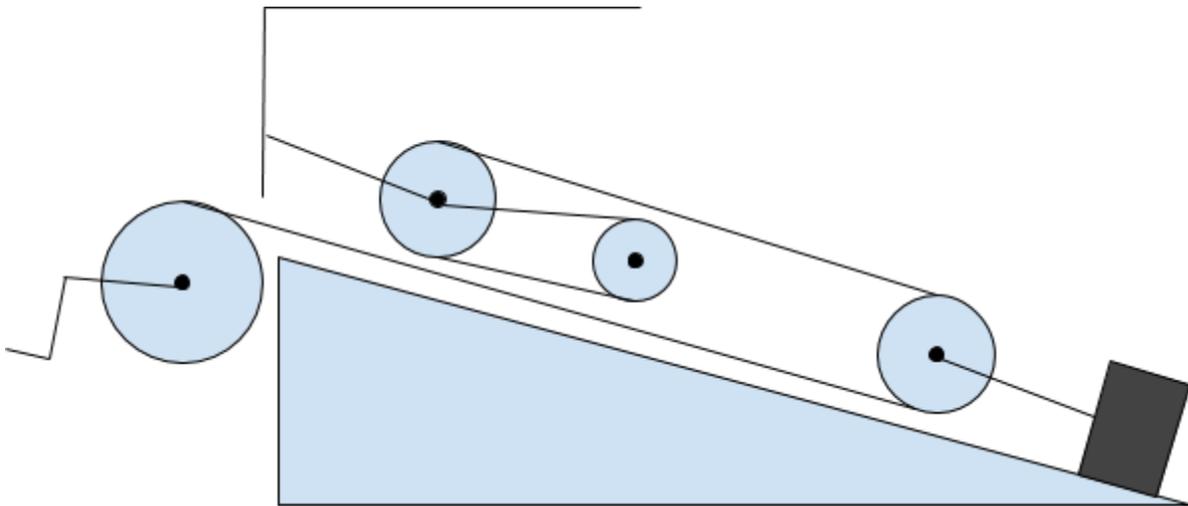
10. The following complex gear train is comprised of 4 gears with: 10 teeth, 20 teeth, 12 teeth, and 15 teeth respectively. Determine the gear ratio between the first and last gears. (3)
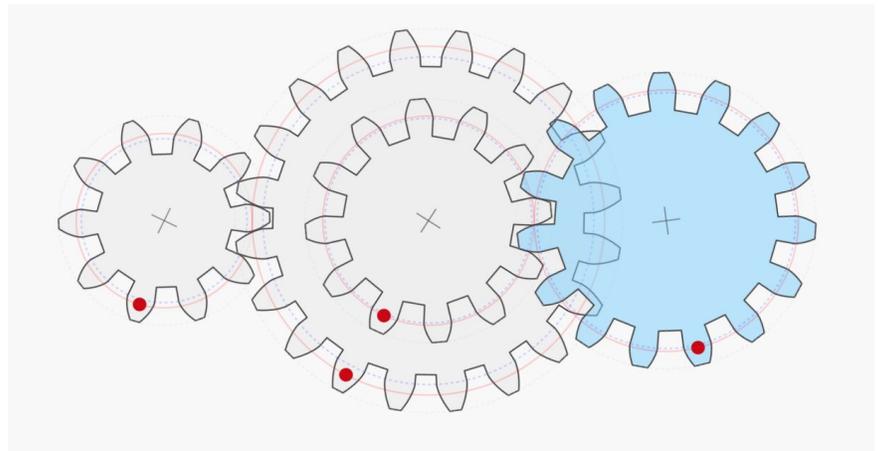
Answer Sheet

Matching:

1.	2.	3.	4.	5.
6.	7.	8.	9.	10.

Multiple Choice:

1.	2.	3.	4.	5.	6.
7.	8.	9.	10.	11.	12.

Free Response:

1.

    a. _____, _____, _____

    b. _____, _____, _____

    c. _____, _____, _____

2.

3. a.   b.

4.

5.

6. a.

b.

c.

7. a.

b.

8. a.

b.

c.

9.

10.