MACHINES

See General Rules, Eye Protection & other Policies on www.soinc.org as they apply to every event.

1. **DESCRIPTION:** Teams will complete a written test on simple, **Division B**, and compound, **Division C**, machine concepts and construct a lever-based measuring device prior to the tournament to determine the ratio between two masses.

   A TEAM OF UP TO: 2 **EYE PROTECTION:** B **IMPOUND:** Yes **EVENT TIME:** 50 minutes

2. **EVENT PARAMETERS:**
   a. Each team may bring one three-ring binder of any size containing information in any form and from any source attached using the available rings. Sheet protectors, lamination, tabs and labels are permitted. Participants may remove information or pages for their use during the event.
   b. Each team may also bring tools, supplies, writing utensils, and two stand-alone calculators of any type for use during any part of the event. These items need not be impounded.
   c. Each team must impound their device, a device diagram, and copies of graphs and/or tables for scoring.
   d. All participants must properly wear eye protection **during Part II – Device Testing**. Participants without proper eye protection must be immediately informed and given a chance to obtain eye protection if time allows. Participants without proper eye protection will not be allowed to compete in **Part II – Device Testing**.
   e. Event Supervisors will supply three masses labeled A, B, and C. A flexible loop, large enough to pass a standard golf ball through, must be tied to the top of each mass. The loops may be made from fishing line, zip ties, string, etc. The masses, including the fully stretched out flexible loop, must be able to fit inside a 15.0 cm x 15.0 cm x 20.0 cm box. Masses A, B, and C must be between 20.0 and 800.0 g. The ratio of the largest mass to the smallest must not exceed the following limit:

	Regionals	States	Nationals
Division B	4:1	5.5:1	7:1
Division C	8:1	10:1	12:1

   f. Participants must be able to answer questions regarding the design, construction, and operation of the device per the Building Policy found on www.soinc.org.

3. **CONSTRUCTION PARAMETERS:**
   a. The device must fit inside a box no larger than 100.0 cm x 100.0 cm x 50.0 cm (at impound).
   b. **Division B:** The device must be a class 1 lever with a single beam no longer than 80.0 cm. **Division C:** The device must be a class 1 lever connected directly in series to a class 2 or 3 lever, each with a single beam of length less than or equal to 40.0 cm.
   c. The device may be made out of any materials. Electric or electronic components are prohibited.
   d. The device must be constructed to accommodate the masses, and must not include springs.
   e. Participants must not bring masses or include them in devices except when fixed in place prior to impound to obtain static equilibrium. Lightweight adjustable sliding hooks used solely to accommodate the masses are allowed and need not be fixed in place.
   f. Prior to competition, teams must calibrate devices by preparing graphs/tables showing the relationship between masses and device configuration parameters. A labeled device diagram should be included.
      i. Any number of graphs and/or data tables may be submitted but the team must indicate up to four to be used for the Chart Score, otherwise the first four provided are scored.
      ii. Graphs and/or tables may be computer generated or drawn by hand on graph paper. Each data series counts as a separate graph. A template is available at www.soinc.org.
      iii. Teams are encouraged to have a duplicate set to use, as those submitted may not be returned.

4. **THE COMPETITION:**

   Part I: Written Test
   a. Teams will be given a minimum of 20 minutes to complete a written test consisting of multiple choice, true-false, completion, or calculation questions/problems.
   b. Unless otherwise requested, answers must be in metric units with appropriate significant figures.

c. The test will consist of at least three questions from each of the following areas:

	Division B	Division C
Concepts, e.g., types and terminology	Simple machines only	Simple and compound machines
Calculations	Ideal and actual mechanical advantage, efficiency, load, and effort as applied to simple machines	Division B topics extended to include compound machines, plus potential and kinetic energy and coefficient of friction

d. Questions are limited to the following simple machines (or, in Division C, combinations thereof) in static equilibrium and must include at least five of the following topics:
   i. Lever (all three classes)
   ii. Inclined plane
   iii. Wedge
   iv. Wheel and axle (including gears)
   v. Pulleys
   vi. Division C Only: Screw

e. Topics prohibited in either division: Dynamic calculations, material strength, and angle of repose.

Part II: Device Testing

a. The objective is to quickly determine the ratios of three unknown masses using a simple lever in Division B or compound lever in Division C.
b. At the start of the competition block, teams will be given 5 minutes to set up or modify their devices and use their graphs and/or tables to calibrate them. Devices that do not meet the construction specs will not be allowed to be tested until brought into specification.
c. While all teams are working on Part I, the Event Supervisor will individually call each team to a station. Multiple identical stations may be used, but all teams will use identical masses.
d. Part II timing (not to exceed 4 minutes) begins when the Event Supervisor provides the masses to the team. The Supervisor must ensure that the mass values are not revealed to any teams. Teams must not touch the masses until time begins.
e. Using the basic physical principles of a lever and adjusting only the relative positions of the masses and/or fulcrum(s) along the lever beam(s), teams must calculate the ratios of the masses. Teams may work with either two or three masses at a time. Teams may use their resources, calculators, and tools to determine mass ratios.
f. Teams must not mark on, attach anything to, or modify the masses.
g. Part II timing stops when the team provides the Supervisor with the calculated mass ratios A/B and B/C or 4 minutes has elapsed. Event Supervisors must record the elapsed time in seconds to the precision of the timing device. No changes are allowed to the calculated values once timing stops.
h. The Supervisor will review with the team the Part II data recorded on their scoresheet.
i. Teams filing an appeal regarding Part II must leave their device in the competition area.

5. **<u>SCORING</u>:**

a. High score wins; Final Score (FS) = ES + R1 + R2 + TS + CS. The maximum possible FS score is 100 points. A scoring spreadsheet is available at www.soinc.org.
b. Exam Score (ES) = (Part I score / Highest Part I score for all teams) x 45 points.
c. Time Score (TS) = ((240 - team's part II time in seconds) / 240) x 15 points.
d. Ratio Scores (R1 and R2) = (1 - (abs(AR - MR) / AR)) x 15 points. The smallest possible R1 and R2 is 0. AR is the actual ratio of two of the masses (measured to the best precision of the equipment available to the Event Supervisor) and MR is the measured value of the ratio as submitted by the team. R1 uses mass ratio A/B, R2 uses mass ratio B/C.

e. Chart Score (CS): One of the submitted graphs/tables, selected by the Event Supervisor, is scored using i., ii., and, iii., described below for a maximum of 6 points. Four (4) additional CS points are available via items iv. and v. Partial credit may be given. A device must be present to receive a CS.
   i. 2 points for including data spanning the possible mass range
   ii. 2 points for including at least 10 data points in each data series
   iii. 2 points for proper labeling (e.g., title, team name, units)
   iv. 0.5 points for each distinct graph or table turned in (up to 2 points total)
   v. 2 points for including a labeled device diagram
f. If a team violates a COMPETITION rule, their TS, R1, and R2 scores will be multiplied by 0.9.
g. If any CONSTRUCTION violation(s) are corrected during the competition block, or if the team misses impound, their TS, R1, and R2 will be multiplied by 0.7.
h. Teams with no device, no ratio estimates, or that do not make an honest attempt to utilize a device of the prescribed type to determine the mass ratios receive R1, R2, and TS of 0. Such teams will be allowed to compete in Part I (the written test).
i. Tie Breakers: 1st - Best ES; 2nd - Best TS; 3rd - Best R1; 4th - Best R2.

Recommended Resources: The Science Olympiad Store (store.soinc.org) carries the classic Machines Lecture Video and the Chem/Phys Science CD; other resources are on the event page at soinc.org.