

**Instructions** (shown before students start the test)

## 2021 UT - Regional Machines C Test

Per Texas Science Olympiad rules, you must have printed notes for this event. If you are communicating with your partner through a voice or video call, please start it before you begin the test itself.

Significant time spent outside of the browser window is grounds for a penalty or disqualification per TSO policies.

**Introduction** (shown after students start the test)

## 2021 UT - Regional Machines C Test

Directions:

Each team will be provided 50 minutes to complete this test.

There is no penalty for wrong answers so make educated guesses when you are unsure.

Some questions will ask you to select all of the correct answers but that does not necessarily mean that there is always more than one correct answer.

MiniSO relies on the honor code so please do not cheat.

This test is meant to be long, so looking questions up will put you at a disadvantage.

Placements will be determined by the total number of points earned.

The tie breakers are as follows: #40: TIE BREAKER QUESTION, #7, #9, #16, #18, #25, #28, #34, #35, #39

Good Luck!

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**1. (0.85 pts)** In a wheel and axle, the resistance force is typically exerted on the axle.

☐ True ☐ False

**2. (0.85 pts)** A simple machine can multiply the amount of inputted energy into output energy.

☐ True ☐ False

**3. (0.85 pts)** Wedges can have any mechanical advantage from 0 to infinity, non-inclusive.

☐ True ☐ False

**4. (0.85 pts)** Using a longer bolt, will get you a larger mechanical advantage.

☐ True ☐ False

**5. (0.85 pts)** Ideal machines can sometimes have an efficiency of above 1.

☐ True ☐ False

**6. (0.85 pts)** Going up a gear in a manual car(ex. 1st gear to 2nd gear), increases the gear ratio.

☐ True ☐ False

**7. (0.85 pts)** After riding a bike for long periods of time, the tire will wear out and the it's diameter will slightly decrease. This decreases the mechanical advantage of the bike.

☐ True ☐ False

**8. (0.85 pts)** If an object remains stationary, that means that no forces are exerted on it.

☐ True ☐ False

**9. (0.85 pts)** A car travels in a uniform circle and then starts to increase speed. The centripetal force acting on the car is no longer facing perpendicular to the car's velocity.

☐ True ☐ False

**10. (0.85 pts)** A compound machine can multiply the amount of inputted force into output force.

☐ True ☐ False

**11. (1.00 pts)** The IMA of a simple machine of  $5/2$ . What is the input force if the output force is equal to 82.5 N.

**12. (1.00 pts)**

There exists a compound machine that is made up of 4 separate simple machines with the following mechanical advantages: 2, 5,  $7/2$ , and  $1/7$ . What is the equivalent mechanical advantage of the compound machine?

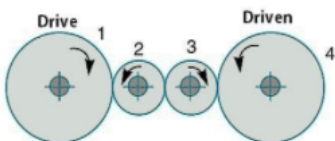
**13. (1.00 pts)**

Rowers use oars to propel their vehicle forward. From the reference point of the location where the end of the oar touches the water, what class lever is this simple machine?



- ☐ A) 1st class
- ☐ B) 2nd class
- ☐ C) 3rd class
- ☐ D) 4th class
- ☐ E) None of the above

**14. (1.00 pts)** How many idler gears are in this gear train?



**15. (2.00 pts)** What type of simple machines are in this wine opener?

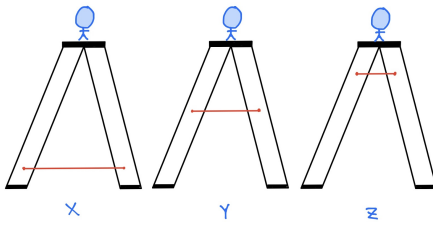


(Mark **ALL** correct answers)

- ☐ A) Lever
- ☐ B) Wheel and axle
- ☐ C) Inclined Plane
- ☐ D) Wedge
- ☐ E) Screw
- ☐ F) Gear

**16. (2.00 pts)**

The Blue Man group stands on top of 3 identical ladders. However, on each ladder a red nylon string is positioned differently. Rank the tensions in order of increasing magnitude. Examples of acceptable answers: XYZ or ZYX or YZX ....



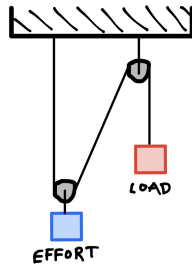


FIGURE 1

**17. (2.00 pts)** [Figure 1] What is the ideal mechanical advantage of this pulley system?

**18. (2.00 pts)** [Figure 1] If the Red Load block travels at 12 m/s, what is the linear velocity of the Blue Effort block?

19. (3.00 pts)

[Figure 1] The pulleys have a diameter of 0.2m. Referring to the velocities from the previous question, what is the angular velocity of the pulley on the right? Answer using the format: Cpi, where C is a constant, and pi is the 3.1415....

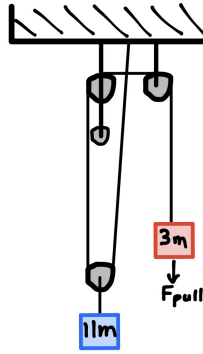


FIGURE 2

20. (3.00 pts)

[Figure 2] How much force must a person pull downwards on the Red(3m) block in order for the pulley system to reach static equilibrium? Answer using the format: Cm, where C is a constant.

21. (3.00 pts) [Figure 2] If the pulley system is allowed to move freely, what is the magnitude of the red block's acceleration? (use  $10 \text{ m/s}^2$  for  $g$ )

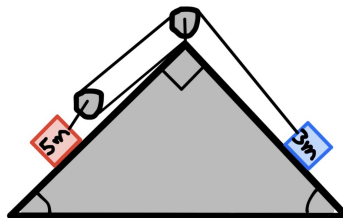


FIGURE 3

22. (2.00 pts) [Figure 3] Does the Red(5m) block move up or down the ramp if both blocks are allowed to move freely. Acceptable answers: up,down.

**23. (2.00 pts)** [Figure 3] What is the ratio of the acceleration of the Red block to the acceleration of the Blue block.

**24. (1.00 pts)** [Figure 3] Which pulley has the lowest angular velocity, the one in the middle or the one on the left? Acceptable answers: middle, left.

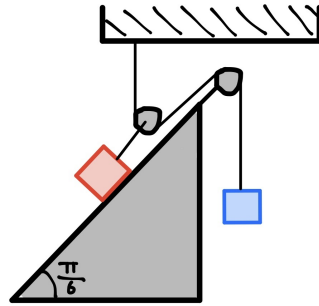
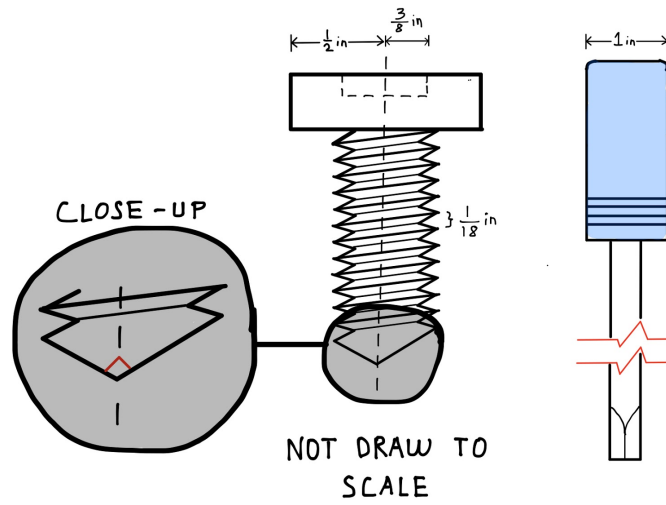


FIGURE 4

**25. (3.00 pts)** [Figure 4] What is the ratio of the mass of the Red block(on the ramp) to the mass of the blue block if the system is in static equilibrium?

**26. (3.00 pts)**

[Figure 4] Perhaps the system is not in static equilibrium, but rather the block accelerates downwards. After falling a certain distance, the blue block gains 2000J of kinetic energy. How much distance has the red block traveled up the ramp if it weighs 10 kg? (use  $10 \text{ m/s}^2$  for  $g$ )



27. (1.00 pts) [Figure 5] What is the TPI of the screw?(Threads per inch)

28. (2.00 pts) [Figure 5] If the screw is 65/18 inches long, how many times would the screw have to be rotated in order to fully lodge itself into a piece of wood?

29. (2.00 pts)

[Figure 5] A screwdriver can be used to rotate a screw. However, on its own it acts as a wheel and axle. What is the mechanical advantage of this screwdriver if it serves as a wheel and axle?

30. (2.00 pts) [Figure 5] The sharp tip of the screw can serve as a wedge if used to apply a force on an object. What is the mechanical advantage of this wedge?

31. (5.00 pts) [Figure 5] If a 25 N force is applied to rotate the screwdriver, which in turns rotate the screw, at what force, does the screw drive into a piece of wood?

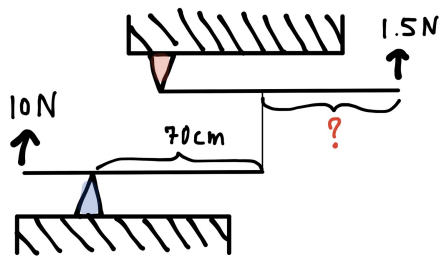


FIGURE 6

32. (4.00 pts)

[Figure 6] Two 1 meter levers are connected together by a vertical nylon string that does not stretch. If 10 N is applied upwards on the left side of the 1st lever and a 1.5 N force is applied upwards on the right side on the 2nd lever, what is the missing distance indicated by the question mark in **centimeters**?

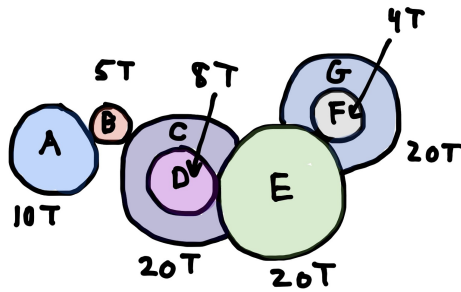


FIGURE 7

33. (2.00 pts)

[Figure 7] The numbers in the diagram represent the number of teeth each gear has. If a motor was attached to one of the gears, which gear would have the greatest angular velocity? Acceptable answers: A,B,C,D,E,F,G.

34. (2.00 pts)

[Figure 7] The numbers in the diagram represent the number of teeth each gear has. If a motor was attached to one of the gears, which gear would have the greatest linear velocity of a point on their outer perimeter? Acceptable answers: A,B,C,D,E,F,G.

35. (3.00 pts)

[Figure 7] The numbers in the diagram represent the number of teeth each gear has. If a motor was attached to one of the gears, rank the gears in order of decreasing torque values out of the following gears: A,B,C,E,. Examples of acceptable answers: ACEB or BAEC or CEBA ....

**36. (3.00 pts)**

[Figure 7] The numbers in the diagram represent the number of teeth each gear has. If a motor was attached to one of the gears, rank the gears in order of decreasing angular velocity values out of the following gears: B,C,E,F. Examples of acceptable answers: BCEF or FBEC or CEFB ....

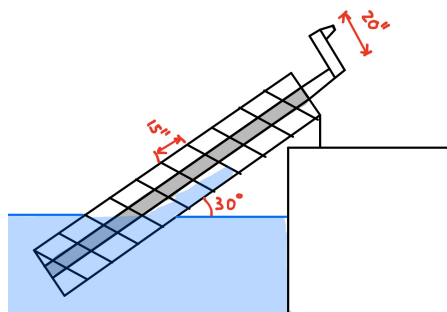


FIGURE 8

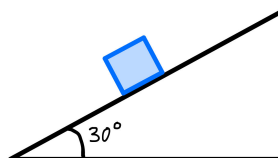
**37. (5.00 pts)**

[Figure 8] The compound machine shown in the figure is known as Archimedes screw. By rotating the lever arm at the top, water is brought towards the top of the screw. What is the mechanical advantage of the Archimedes screw?

**38. (1.00 pts)**

[Figure 8] By looking at the orientation of the threads on the Archimedes screw, which direction should you rotate the lever arm to move the water up the screw? Answer CW for clockwise and CCW for counterclockwise.

**39. (3.00 pts)** There is a block that sits on a ramp. If the block remains stationary on the ramp, what is the minimum coefficient of friction between the block and ramp?




**40. (0.10 pts)**

**TIE BREAKER QUESTION:** Compound machines are typically used in the real world to exert extremely high forces. A lever, given an extremely long input arm and extremely short output arm, can also exert high forces of similar magnitudes to those of compound machines. However, you typically don't see construction workers use a single lever to lift massive metal beams. From an engineering/practical standpoint, why is it a bad idea to use a lever for lifting bulky building materials? List as many reasons as you can.



We hope you enjoyed this exam! If you have any feedback about any of the exams at this tournament, please let us know through this form: <https://tinyurl.com/utreg21feedback>  
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