Machines C - Machines C - UT Invitational 2020 - Division C - 11-08-2020

Welcome to the UT Fall 2020 Machines C Test!

A few things to note:

- There is a true/false section, a multiple-choice section, and a short-answer section
- Assume that the acceleration due to gravity is $9.8m/s$
- Ties will be broken based on the first true/false question that is missed
- If you have any questions during or after the test, please contact me at justinoca@utexas.edu
- Good luck and have fun!

1. (1.00 pts) Ideal mechanical advantage depends on the efficiency of the machine

○ True ○ False

2. (1.00 pts) Friction works in the opposite direction of the motion of object

○ True ○ False

3. (1.00 pts) In any closed system, the amount of energy present is always constant

○ True ○ False

4. (1.00 pts) Power is the distance derivative of energy

○ True ○ False

5. (1.00 pts) A lever with the effort in the middle is a class two lever

○ True ○ False

6. (1.00 pts) A machine makes work easier by increasing the energy output

○ True ○ False

7. (1.00 pts) The coefficient of kinetic friction is typically higher than the coefficient of static friction

○ True ○ False

8. (1.00 pts) Work is the dot product of force and displacement

○ True ○ False

9. (1.00 pts) If an object is at rest, then there are no forces acting on it

○ True ○ False

10. (1.00 pts) Actual mechanical advantage is dependent on the input and output forces

○ True ○ False

11. (1.00 pts) A wheel and axle system in equilibrium has balanced torques acting on it

○ True ○ False

12. (1.00 pts) A machine is able to change the direction of a force

○ True ○ False

13. (1.00 pts) For a machine, it is possible for its actual mechanical advantage to exceed its ideal mechanical advantage

○ True ○ False

14. (1.00 pts) A machine is 'self-locking' has an efficiency of less than 50%

○ True ○ False

15. (1.00 pts) Torque is the rotational analog for force

○ True ○ False

16. (1.00 pts) Force is the time derivative of impulse

○ True ○ False

17. (1.00 pts) When two objects collide inelastically, their kinetic energies are conserved

○ True ○ False

18. (1.00 pts) The normal force points tangent to the surface of contact

○ True ○ False

19. (1.00 pts) A mass sliding down a frictionless ramp has smaller acceleration than if it were dropped from the same height

○ True ○ False

20. (1.00 pts) A mass sliding down a frictionless ramp has a smaller final kinetic energy than if it were dropped from the same height

○ True ○ False

21. (3.00 pts) What conditions are needed for a machine to be "ideal"?

○ A) Its work output must be equal to its input work
○ B) No heat or sound is produced
○ C) Its IMA and AMA are equivalent
○ D) All of the above

22. (3.00 pts) What is the correct formula for the efficiency of a machine?

○ A) (input distance)/(output distance)

B) (output force)/(input force)

C) (actual mechanical advantage)/(ideal mechanical advantage)

D) (ideal mechanical advantage)/(actual mechanical advantage)

23. (3.00 pts) A given machine has an input distance of d and has an output distance of 2d. What does this tell us?

A) The machine has an ideal mechanical advantage of 0.5

B) The machine has an ideal mechanical advantage of 2

C) The machine has an actual mechanical advantage of 0.5

D) The machine has an actual mechanical advantage of 2

24. (3.00 pts) A given machine has an input force of F and has an output force of 2F. What does this tell us?

A) The machine has an ideal mechanical advantage of 0.5

B) The machine has an ideal mechanical advantage of 2

C) The machine has an actual mechanical advantage of 0.5

D) The machine has an actual mechanical advantage of 2

25. (3.00 pts) Which of the following statements mechanical advantage is true?

A) Mechanical advantage relates the input and output forces

B) Mechanical advantage describes the efficiency of a machine

C) Mechanical advantage changes depending on the force being applied

D) Mechanical advantage depends on the type of machine being operated

26. (3.00 pts) Which of the following statements regarding simple machines in true?

A) A simple machine can alter the efficiency of a task

B) A simple machine can change the magnitude and direction of a force

C) A simple machine can output more work than inputted

D) A simple machine can output more power than inputted

27. (3.00 pts)
A machine has an ideal mechanical advantage of 0.80 and an actual mechanical advantage of 0.75. If the input force was applied for 20 meters, how far does the load move?

A) 12 m

B) 16 m

C) 15 m

D) 20 m

28. (3.00 pts) A machine has an ideal mechanical advantage of 4 and an actual mechanical advantage of 3. If the input force is 60 N, what is the output force?

A) 15 N

B) 240 N

C) 20 N

D) 180 N

29. (3.00 pts) A machine has an ideal mechanical advantage of 12 and an efficiency of 0.75. What is the actual mechanical advantage?

A) 3
B) 4
C) 9
D) 16

30. (3.00 pts) A machine has an actual mechanical advantage of 12 and an efficiency of 0.75. What is the ideal mechanical advantage?

A) 3
B) 8
C) 16
D) 4

31. (3.00 pts) An object with a mass of 3.0 kg moves with a constant velocity of 4.0 m/s. What is the kinetic energy of the object?

A) 12 J
B) 24 J
C) 48 J
D) 96 J

32. (3.00 pts) An object with a mass of 2.0 kg is lifted a height of 3.0 m. What is the change in potential energy of the object?

A) 50 J
B) 54 J
C) 59 J
D) 60 J

33. (3.00 pts) A machine has an input force of 40 N and an input distance of 3.0 meters. If the machine has an efficiency of 80%, then what is the output work of the machine?

A) 96 J
B) 120 J
C) 150 J
D) 190 J

34. (3.00 pts)
A machine has an output work of 120 J and the work is done over the course of 15 seconds. If the machine has an efficiency of 40%, then what is the input power of the machine?

A) 3.2 W
B) 8.0 W
C) 20 W
D) 45 W

35. (3.00 pts)
Given a semicircular ramp, if an object is released at a point 50.0 m above the ground, what speed will it have at the bottom of the ramp (assuming that the incline is frictionless)?

A) 22.1 m/s
B) 31.3 m/s
C) 7.07 m/s
D) 10.0 m/s

36. (3.00 pts)

A bullet has a mass of 25 g and a wooden block has a mass of 375 g. If the bullet has an initial speed of 600 m/s and the wooden block is initially at rest, what is the resultant velocity of both objects (assuming a perfectly inelastic collision)?

- A) 40.0 m/s
- B) 563 m/s
- C) 37.5 m/s
- D) 600 m/s

37. (3.00 pts)
A block with a mass of 5.0 kg rests on a surface with a coefficient of static friction of 0.20 and a coefficient of kinetic friction of 0.15. What force is needed to move the block at a constant velocity?

- A) 49 N
- B) 7.4 N
- C) 9.8 N
- D) 5.0 N

38. (3.00 pts)
A wheel and axle system is used to raise a bucket out of a water well. The wheel arm has a radius of 50.0 cm, the axle arm has a radius of 10.0 cm, and the well is 15.0 m deep. What is the ideal mechanical advantage of the wheel and axle system and how many rotations are needed to raise the bucket out of the well?

- A) ideal mechanical advantage = 5 and 23.9 rotations
- B) ideal mechanical advantage = 0.2 and 4.77 rotations
- C) ideal mechanical advantage = 5 and 150 rotations
- D) ideal mechanical advantage = 0.2 and 30 rotations

39. (3.00 pts)
A wheel and axle system is used to raise an object with a mass of m. If the wheel has a radius of R and the axle has a radius of r, what is the input force needed to lift the mass?

- A) $\frac{mgR}{r}$
- B) $\frac{r}{mgR}$
- C) $\frac{mgr}{R}$
- D) $\frac{R}{mgr}$

40. (3.00 pts) A wheelbarrow is used to carry some soil. What class lever is this?

- A) Class 1
- B) Class 2
- C) Class 3
- D) More information needed

41. (3.00 pts)
A child leans against the center of a door and prevents it from being opened. The child has a mass of 50 kg and a coefficient of static friction of 0.3 with the floor. What force must be applied to the edge of the door in order to overcome the force from the child?

- A) 150 N
- B) 490 N
- C) 250 N
- D) 74 N

42. (3.00 pts)
Heather and Hector are both sitting on opposite sides of a seesaw of length 4.0 meters. Heather has a mass of 60 kg and Hector has a mass of 75 kg. If Heather sits at the very edge of one end of the seesaw, how far away should Hector sit from the fulcrum in order to maintain equilibrium?

A) 2.0 m
B) 2.5 m
C) 1.6 m
D) 3.2 m

43. (3.00 pts) An inclined plane has a length of 2.0 m and an angle of elevation of 25 degrees. What is the height of the inclined plane?

A) 1.8 m
B) 0.85 m
C) 0.93 m
D) 4.3 m

44. (3.00 pts)
Greta is pushing a box up an incline of 15.0 degrees. If the box has a mass of 40.0 kg, then what is the constant force that she must apply in order to push the box at a constant velocity (assuming that the incline is frictionless)?

A) 379 N
B) 406 N
C) 101 N
D) 105 N

45. (3.00 pts)
Penelope is testing out a small ramp as a science experiment. She places a paperclip at the top of the ramp and notes that it accelerates at a rate of 2.0 m/s^2 down the ramp. It is known that the ramp forms an angle of 30 degrees with horizontal. Using this information, determine the coefficient of kinetic friction with the ramp.

A) 0.18
B) 0.53
C) 0.92
D) 0.34

46. (3.00 pts)
A box with a weight of 40 N is being pushed along a frictionless inclined plane with an angle of elevation of 15 degrees. If the box travels a distance of 2.0 meters along the incline, then how much work is done on the box?

A) 80 J
B) 21 J
C) 310 J
D) 77 J

47. (3.00 pts)
Daniel wants to sled down a snowy hill with an incline of 6.0 degrees. If the slope is 50.0 m long and the coefficient of kinetic friction is 0.05, then what is Daniel's speed upon reaching the bottom of the hill?

A) 7.3 m/s
B) 2.3 m/s
C) 7.0 m/s
D) 10 m/s

48. (3.00 pts)
A wooden plank is used as a ramp to slide some boxes into the back of her car trunk. One end of the plank sits on the ground while the other end rests on the edge of the trunk. If the plank is considered to be an inclined plane with an angle of 35.0 degrees with horizontal, what is its ideal mechanical advantage (assuming that the incline is frictionless)?

A) 1.22

B) 0.57

C) 1.74

D) 0.82

49. (3.00 pts) A wedge has a length of l and a width of w. If a force of F is applied at the top of the wedge, what is the force of separation?

A) $\frac{Fw}{l}$

B) $\frac{l}{Fw}$

C) $\frac{w}{Fl}$

D) $\frac{Fl}{w}$

50. (3.00 pts)
An axe has a wedge length of 20 cm and a width of 1.5 cm. If a tree requires a force of 800 N to completely cut through its trunk, what input force is needed from the axe?

A) 107 N

B) 60.0 N

C) 40.0 N

D) 533 N

IMPORTANT - MUST READ

For the next section, Scilympiad will only accept your answer if it is in a specific format. Make sure to do the following:

- utilize the correct significant figures for your answer
- do not use scientific notation
- do not include units in your answer (the units needed are in parenthesis at the end of the question)

Examples:

A box has a mass of 1 kg. What is its weight (N)?

Correct Answer Format: 10

Incorrect Answer Format: 10 N, 10.0, 9.8, 9.8 N, 1e1

An object travels 36 meters in 7.0 seconds. What is its speed (m/s)?

Correct Answer Format: 5.1

Incorrect Answer Format: 5.1 m/s, 5.14, 5 m/s, 5.10

Use the following information for questions 51-56:

A rubber wedge is kicked underneath the center of a door to keep it in place. This works because the downward force from the door on the wedge and the ground provides enough static friction to keep it motionless. The wedge has a length of 15 cm and a height of 3.0 cm and there is a coefficient of static friction of 0.60 between the wedge and the floor. Assume that the wedge and door are weightless.

51. (4.00 pts) If the wedge is initially kicked horizontally under the door with a force of 60 N, then what is the force of separation from the wedge (N)?

52. (4.00 pts) What is the normal force between the wedge and the floor (N)?

53. (4.00 pts) What is the frictional force between the wedge and the floor (N)?

54. (4.00 pts) What is the maximum resistive force that the wedge can exert on the door (N)?

55. (4.00 pts)
What is the minimum force needed to move the door from its position? Remember that the door handle is at the edge of the door while the wedge is positioned underneath the center of the door (N).

56. (4.00 pts)
If the door and wedge are considered together as a compound machine and the force on the door handle is considered a load, then what is the actual mechanical advantage of the compound machine?

Use the following information for questions 57-60:

A carpenter is using a drill to screw through a thick piece of wood. The screw has a radius of 4.0 mm and a pitch length of 3.0 mm. Assume that there are no energy losses to heat or sound.

57. (4.00 pts) What is the ideal mechanical advantage of the screw?

58. (4.00 pts) How many rotations from the drill would be needed for the screw to go through 3.0 cm of wood?

59. (4.00 pts) If the drill can supply 4 Nm of torque, then what is the force at the tip of the screw (N)?

60. (4.00 pts) How much energy is used in drilling in the screw (J)?

Thank you and good luck on the rest of your tests!