

**ANSWER KEY**

Student \_\_\_\_\_

Class \_\_\_\_\_

**MECHANICAL SYSTEMS - Reference Page**

Refer to the following **Formulas** that you may need to use throughout this exam

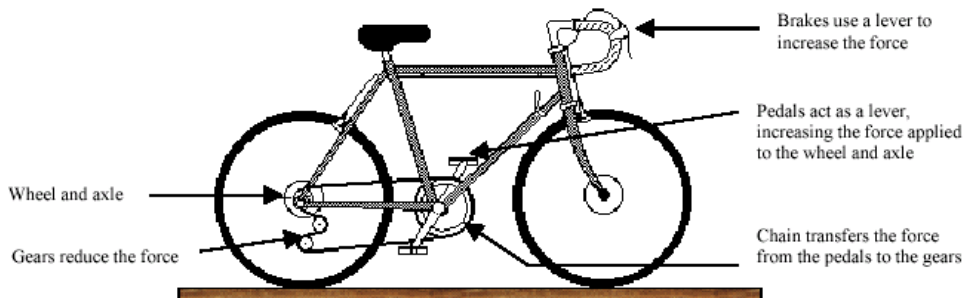
$$MA = \frac{\text{Output Force}}{\text{Input Force}}$$

$$MA = \frac{F_{\text{output}}}{F_{\text{input}}}$$

$$SR = \frac{\text{Input distance}}{\text{Output distance}}$$

$$SR = \frac{d_{\text{input}}}{d_{\text{output}}}$$

$$\text{Efficiency} = \frac{\text{Mechanical Advantage}}{\text{Speed Ratio}} \times 100$$



$$W = F \times d$$

$$\text{Work}_{\text{input}} = \text{Force}_{\text{input}} \times d_{\text{input}}$$

$$\text{Work}_{\text{output}} = \text{Force}_{\text{output}} \times d_{\text{output}}$$

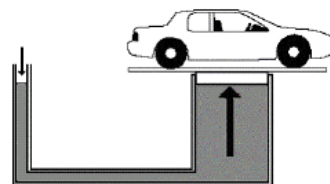
$$\text{Efficiency} = \frac{\text{Work}_{\text{output}}}{\text{Work}_{\text{input}}} \times 100$$

$$p = F / A$$

$$MA = \text{Output force} / \text{Input force}$$

$$MA = F_o \times d_o / F_i \times d_i$$

$$\frac{F_{\text{small}}}{A_{\text{small}}} = \frac{F_{\text{large}}}{A_{\text{large}}}$$



### Numerical Response Questions

**NR1** - A block and tackle pulley system is used to lift heavy machinery in the CTS room. One machine is 223 kg. To lift it into place where it is going to be used, it has to be raised 1.2m off the floor.

How much work is being done to raise the machine onto its platform?

(Show your work)

2	6	7	6
---	---	---	---

	.	.	
0	0	0	0
1	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	7
8	8	8	8
9	9	9	9

**NR2** - To test the success of a protective egg carton (which has a mass of 200g), Jacobs (who has a mass of 60kg), carried it up to the roof. It was dropped from a height of 4m.

How much work was done by Jacobs to test the egg protection device?

(Show your work)

1	2	0	8
---	---	---	---

	.	.	
0	0	0	0
1	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	7
8	8	8	8
9	9	9	9

**NR3** - The pulley system illustrated here was used to lift a heavy load.



If 340N of force is used, how much force is the pulley system able to overcome?

(Show your work)

1	0	2	0
---	---	---	---

	.	.	
0	0	0	0
1	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	7
8	8	8	8
9	9	9	9

**NR4** - The work done by a lever is 5225J. The work done by the effort force is 8650J.

What is the efficiency of the lever?

(Show your work)

6	0	.	4
---	---	---	---

	.	.	
0	0	0	0
1	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	7
8	8	8	8
9	9	9	9

**NR5** - Your grandfather gave you his bicycle. As you push down on the pedals you find that you are exerting 797N of force. The resulting load force causing the bicycle to move forward is 104N.

What is the mechanical advantage of the bicycle?

(Show your work)

0	.	1	3
---	---	---	---

	.	.	
0	0	0	0
1	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	7
8	8	8	8
9	9	9	9

**NR6** - A hydraulic lift was used to lift a load of 264N up three shelves high in a warehouse. The operator found that the distance it moved was 3.2m. If the mechanical advantage of the hydraulic lift was 10.

How much effort force was needed to lift the load?

(Show your work)

2	6	.	4
---	---	---	---

	.	.	
0	0	0	0
1	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	7
8	8	8	8
9	9	9	9

Section 1.0 Machines are tools that help humans do work.

### 1.1 Simple Machines – Meeting Human Needs

1. The first machines depended on these for their source of energy ...  
**A electricity and coal**  
**B natural gas and wood**  
**C humans and animals**  
**D steam and wood**
2. Archimedes designed a system for moving water from one place to another. His machine is still used today. It is based on the simple machine - the ...  
**A lever**  
**B screw**  
**C wedge**  
**D inclined plane**
3. A simple machine that converts rotational motion to linear motion is called ...  
**A Class 1 lever**  
**B Inclined plane**  
**C Wedge**  
**D Screw**
4. A diving board is an example of a first class lever. The fulcrum is ...  
**A between the load and the effort force**  
**B at one end with the effort force in the middle**  
**C at one end with the load in the middle**  
**D at one end with the effort force at the other end**
5. In most simple machines, you don't get something for nothing. When you gain a force advantage, you usually lose ...  
**A effort**  
**B speed**  
**C distance**  
**D resistance**

### 1.2 The Complex Machine – A Mechanical Team

6. Within the bicycle, there are many different parts that have very different functions. Each of these parts performs a specific function so that the bicycle can perform its overall function – to move you around. The many different parts of the bicycle are called ...  
**A subsystems**  
**B system components**  
**C technological devices**  
**D complicated device**
7. Transmissions are special types of linkages. It is used to transfer energy from the engine to the wheels in a car. A transmission contains a number of these that allow the driver to apply a large force to move objects slowly or a small force to move objects quickly. They are ...  
**A chains**  
**B fan belts**  
**C gears**  
**D linkages**

8. Gears can also change the direction of motion.



In an eggbeater, the crank turns the driving gear, which in turn makes the beaters rotate. The transfer of motion is ...

- A rotational to linear
- B horizontal to vertical
- C linear to rotational
- D vertical to horizontal

9. Gears work together in trains of two or more gear wheels



This gear train is made up of the following gears ...

- A parallel - multiplying - reducing
- B multiplying - parallel - reducing
- C reducing - multiplying - parallel
- D parallel - reducing - multiplying

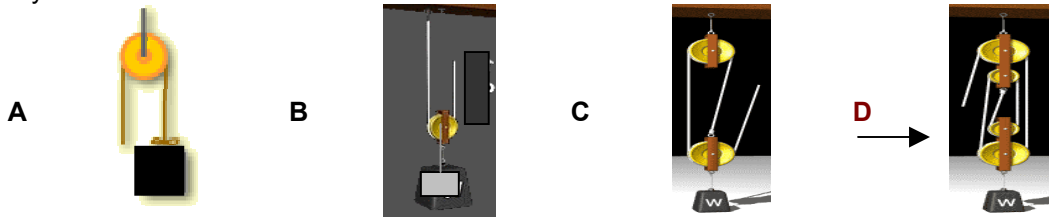
10. On a bicycle, gears are made up of flat, toothed disks called ...

- A linkages
- B sprockets
- C pinions
- D torques

**Section 2.0 An understanding of mechanical advantage and work helps in determining the efficiency of machines.**

**2.1 Machines Make Work Easier**

11. If it takes 45 N of force to lift a 180 N carton using a pulley system, what would the pulley system look like ...



12. Your car has a flat tire, but you don't have a jack to lift it up, so you can change the tire. What machine could you make that would make it possible to lift the car ...

- A lever
- B wedge
- C pulley
- D ramp

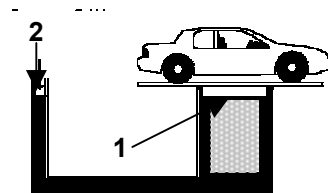
13. To calculate mechanical advantage, or force ratio, you divide the output force by the input force. A machine that is able to move an object that weighs 360 Newtons with 6 Newtons of force has a mechanical advantage of ...
- A 60
  - B 100
  - C 360
  - D 366
14. What can account for the fact that mechanical advantage and speed ratio are always different in real situations?
- A Improper calculations
  - B Faulty equipment
  - C Force of friction
  - D Loss of energy
15. Efficiency is a measure of how well a machine does work. Dividing the mechanical advantage by the speed ratio and multiplying the result by 100 will determine the efficiency of the machine. A pulley system that has a speed ratio of 3 and a mechanical advantage of 2 has an efficiency of ....
- A 33%
  - B 67%
  - C 60%
  - D 30%

## 2.2 The Science of Work

16. Using the scientific definition of work, which statement below describes work being done.
- A Tommy worked very hard to get all his homework done.
  - B Doing science is hard work when you learn formulas.
  - C It was hard work for Jessie to move the desk two meters.
  - D It was hard work but Rick couldn't move the car at all.
17. Work is calculated using the formula –  $W = F \times d$ . If you lift a box onto your desk that is .4 meters off the floor, using 50 Newtons of force, how much work are you doing?
- A 20 Joules
  - B 125 Joules
  - C 50.4 Joules
  - D 49.6 Joules
18. Using a machine does not mean that less work is done. This is because ...
- A Work input is never equal to work output
  - B Work input is equal to work output
  - C Less force means less distance
  - D More force means more distance
19. When determining the efficiency of a certain machine, the students found that 1600J of work were needed to get 1200J of work from the machine. The efficiency of this machine was ...
- A 2800J
  - B 400J
  - C 75 %
  - D 25%

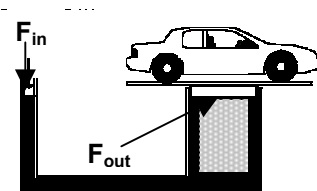
### 2.3 The Big Movers - Hydraulics

20. Hydraulic systems are used in many different applications. A hair stylist would use hydraulics in their shop to do this ...
- A run the neon signs
  - B operate electric shears
  - C mix chemicals and dyes
  - D **raise and lower the chair**
21. **Pascal's Law** states that pressure applied to an enclosed fluid is transmitted ...
- A to the walls of the container which double the pressure
  - B **equally in all directions throughout the fluid**
  - C by the transfer force in the fluid
  - D to the opposite piston where it increases the force
22. A common application of the hydraulic system is the hydraulic jack, like the one shown here ...



The piston identified by # 2 is the ...

- A syringe piston
  - B hoist piston
  - C output piston
  - D **input piston**
23. The mechanical advantage in a hydraulic system is provided by the ...
- A small piston
  - B large piston
  - C flexible connection
  - D **pressure in the fluid**
24. The hydraulic jack, like the one shown here, identifies the input force piston and the output force piston ...
- $F_{in} = 50\text{N}$   
 $F_{out} = 1500\text{N}$



The mechanical advantage of this hydraulic jack is ...

- A 30
  - B 300
  - C 1000
  - D **2000**
25. If the area of the **input piston**, in the hydraulic lift shown in the question above, is  $5\text{cm}^2$ , what would be the area of the **output piston**?
- A  $10\text{cm}^2$
  - B  $30\text{cm}^2$
  - C  **$150\text{cm}^2$**
  - D  $300\text{cm}^2$

**3.1 Evaluating Mechanical Devices**

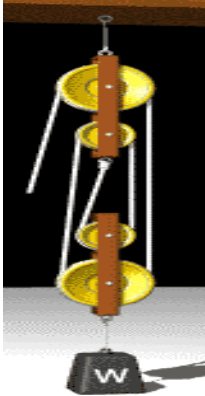
26. During the research phase, when a device is improved upon, certain criteria are taken into account. Of the criteria listed below, which would be the least important ...
- A function
  - B efficiency
  - C effectiveness
  - D convenience
27. Mechanical devices are evaluated so that the consumer who is ultimately going to use it can make a better choice. Another important reason to carefully evaluate a mechanical device is to ...
- A determine how it can be improved
  - B make it more fashionable
  - C find its esthetic value
  - D lower its cost
28. The design of mountain bikes to handle the rough terrain they would be used in, is considered to be evaluating a function because of this influence ...
- A mass appeal
  - B mass demand
  - C environment
  - D ergonomics
29. Opening a can has evolved from the earliest cans which were made from iron in 1810. These can were opened by using a ...
- A church key
  - B push button
  - C removable tab
  - D hammer and chisel
30. The church key was the first practical design for opening a can. It was a simple machine that multiplied the force needed to open the can. The simple machine it was designed after was the ...
- A block and tackle
  - B 1<sup>st</sup> class lever
  - C 2<sup>nd</sup> class lever
  - D 3<sup>rd</sup> class lever

**3.2 Technology Develops Through Change**

31. Another simple machine was built into the removable tab top. It consisted of a small ring that acted like a lever and would make the necessary hole by removing the tab from the can. This was a huge improvement, but it also created a huge problem. The problem it created was ...
- A scientific
  - B environmental
  - C industrial
  - D commercial

32. **CSA** is a non-government association that tests and approves a wide range of products to ensure they are safe for use by the consumer. CSA stands for ...
- A Canadian Standards Agency
  - B Consumer Standards Agency
  - C Consumer Safety Association
  - D **Canadian Standards Association**
33. New technologies often develop from scientific research that seems to be unrelated. Particle accelerator research experiments led to the technology behind trains powered by electricity and magnets. These trains 'float' on the tracks. They are known as ...
- A MAGIC
  - B MALLEG
  - C MAVEEG
  - D **MAGLEV**
34. Improvements in robot technology came as a result of industry trying to ...
- A Improve the assembly of consumer products
  - B Improve the margin of safety in all products
  - C Reducing the workload of the workers
  - D **Replace workers because of high wages**
35. Robots are extremely complex devices and vary widely in appearance, depending on the job they are designed to do. A simple robot however has some or all of these basic parts: body, motor devices, power source, sensors, output devices, microprocessors. **Spirit** and **Opportunity** are robot rovers on the planet Mars. The solar panels on the robots are examples of these basic parts ...
- A Sensors
  - B Motor devices
  - C **Power source**
  - D Microprocessors

36. Use the pulley illustrated to complete this question (Show your work in the space provided)  
What is the **Mechanical Advantage** of this pulley system **and** how much of a load could you lift if you pulled on the rope with 100 N of force?



$$\text{MA} = 4$$

$$\text{Effort Needed} = 100/4 = 25\text{N}$$

How much work are you doing if the rope is pulled 4 m?

$$W = F \times d \quad \text{Work} = 25\text{N} \times 4\text{m} = 100\text{J}$$

37. A different pulley system lifts a 100N load with a force of 20N. The input distance is 3m and the output distance is 0.5m. The efficiency of this pulley system is ...
- A 62.5%
  - B 75.0%
  - C **83.3%**
  - D 92.75%