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Reliance Academy,

Coaching Classes for Diploma Engg.

Subject:Engineering Mechanics

Ch 1. Simple Machines

List Of Types:

Definitions and theory Questions Problems on general Machines

1) Problem of MA,VRand Efficiency of machine.

2) Problems on Friction in machines.

3) Problems on Law of Machines.

Problems on Various Machines

4) Problems on Screw Jack.

5) Problems worm and worm wheel.

6) Problems on Weston's Differential Pulley Block.

7) Problems on Simple and differential pulley block.

8) Problems on Geared Pulley Block.

9) Problems on Single and Double purchase crab.

Theory Question and Answers on Simple Machines

Q.1. Define simple machine and compound machine.

Ans: A simple machine has only **one point for the application of effort and one point for load.** Its mechanism is simple. Some examples of simple machine are Lever,inclined plane,Screw jack

A compound machine has **more than one point for the application of effort and for the load**. Its mechanism is compounded and complicated. Some examples of compound machines are planer machine, lathe machine,shaping machine etc.

Q.2.Define Input and Output of Machine.

Input of Machine : The amount of **work done by effort** on the machine is called input of machine.

$$Input = Effort \times Distance\ moved\ by\ effort$$

$$Input = P \times y$$

Output of Machine : the amount of **work done by load** of the machine is called the output of machine.

$$Output = Load \times Distance\ moved\ by\ Load$$

$$Output = W \times x$$

Q.3. Define Mechanical advantage (MA) , velocity ratio (VR) and Efficiency of the machine.

Ans : Mechanical Advantage : It is defined as the **ratio** of the **load** lifted by the machine to the **effort** applied to lift the load..

$$M.A = \frac{Load\ lifted}{Effort\ Applied} = \frac{W}{P}$$

Mechanical advantage is pure number and it has no unit. It is always greater than 1.

Velocity Ratio : It is defined as the ratio of distance moved by the effort to the distance moved by the load.

$$V.R. = \frac{Distance\ moved\ by\ the\ effort}{Distance\ moved\ by\ load} = \frac{y}{x}$$

Efficiency of a machine: Efficiency of a machine is defined as the ratio of output of a machine to the input to the machine.

$$Efficiency = \frac{Output\ of\ a\ machine}{Input\ to\ a\ machine} = \frac{w \times x}{p \times y} = \frac{w/p}{y/x} = \frac{M.A}{V.R}$$

Q.4. What is meant by ideal machine, Ideal effort,Ideal load?

Ans: If the efficiency of a machine is 100%, then the machine is called Ideal Machine. Such machine has **no frictional losses**.

Ideal effort : It is the effort required to lift the load when there is **no friction** in machine.

$$Ideal\ Effort = P_i = \frac{W}{V.R.}$$

Ideal load : It is the load that can be lifted by a given machine when there is **no friction** in the machine.

$$Ideal\ Load = W_i = P \times V.R.$$

Q.5.Define and State formula of effort and load lost in friction.

Effort lost in friction : It is the additional effort required to overcome the friction.

$$Effort\ lost\ in\ friction = P_f = p - \frac{W}{VR}$$

Load Lost in friction: It is the additional load that might have been lifted by load for given effort when there would have no friction.

$$Load\ Lost\ in\ friction = W_f = P \times VR - W$$

Q.6.Define Maximum M.A. and state its formula.

Ans: The Mechanical Advantage of the machine when friction is not present in the machine is called maximum MA.

Formula for Max M.A. $Maximum\ M.A. = \frac{1}{m}$

Q.7.What is law of machine and state its importance?.

Ans: "Law of machine is an equation which states the relation between effort & load." Law of machine is important because using it we can find effort required for certain load or load that can be lifted with given effort.

Q.8.What is the significance of law of machine?.

Ans: Law of machine gives idea about the load and effort relation of a machine. It also tells us about the friction present in the machine under no load condition.

Law of machine can be used to find the load when effort is known and effort when load is known and also maximum mechanical advantage.

Q.9.What is a reversible machine?

Ans: A lifting machine in which the load starts moving back to its original position when the effort is removed is called reversible machine.

Such machine has efficiency more than 50%.

Q.10.What is a Self-locking machine?

Ans: A lifting machine in which the load remains at its position even when the effort is removed is called self locking machine machine. Example is screw jack

Such machine has efficiency less than 50%.

Q.11.State the condition for reversibility of machine.

Ans: For a lifting machine,

If $\eta > 50\%$ .....$Machine\ is\ reversible$

If $\eta < 50\%$ .....$Machine\ is\ irreversible$ (or self locking)

If $\eta = 50\%$ .....$Machine\ is\ on\ the\ point\ of\ reversing.$

Q. 12. Define effort , State SI Unit

Ans : ***"The force applied to lift the load is called effort ."***SI unit is Newton.

Type 1: Problems on M.A V.R and Efficiency

1. In a simple lifting machine a load of 1400 N is lifted by 50 N effort while the load moves up by 0.2 m the effort moves by 6 m. Calculate 1)M.A 2) V.R. 3) Efficiency.

2.In a certain lifting machine effort has to move through a distance of 1 m when load moves through a distance of 10 mm. Machine lifts a load of 1500 N with the effort of 25 N. find MA ,VR and Efficiency.

3.In a simple lifting machine a load of 5 kN is lifted by 45 N effort. While the load moves up by 30mm the effort moves through 4 m. Calculate MA,VR and efficiency.

4.In a certain lifting machine whose efficiency is 70%, effort has to move through 2m in order to move the load through 50 mm. Determine the effort required to lift a load of 2000 N.

5. Determine the load that can be lifted by a machine whose efficiency is 60% and effort of 50 N moves through distance of 3 m while the load moves through 40mm.

6.A machine has velocity ratio 30, determine the effort required to lift a load of 100N if efficiency of the machine is 30%.

7)In a certain lifting machine whose velocity ratio is 20 and efficiency is 60%. Determine load that can be lifted by effort of 20 N.

Ans 1) MA=28,VR=30,Eff=93.33% 2) MA=60,VR=100,Eff=60%

3) MA=111.11,VR=1333.33,Eff=83.33% 4) P=71.42 N

5) W=2250 N, 6) P=11.11 N , 7) W= 240 N

Type 2 : Problems on Friction in Machines

1] For a certain machine having VR of 40 and efficiency 75%.Calculate the effort lost in friction while lifting a load of 3 KN.

2] In A certain lifting machine load of 100N is lifted by an effort of 8N and efficiency of the machine is 60%.Calculate...

1) effort lost in friction, 2) load lost in friction

3] In a certain lifting machine an effort of 2N lifts a load of 30N.If the effort lost due to friction at this load is 0.5N.Find velocity ratio & efficiency of machine.

4] In a machine ,an effort of 2N lifted a load of 30N. If effort lost due to friction at this load is 0.5NFind ideal effort,mechanical advantage, velocity ratio and efficiency of machine.

5] In a machine an effort of 200N is required to lift a certain load, when its efficiency is 60%. Find the ideal effort.

6]In a machine the effort required to lift certain load is 150N, when efficiency is 65%. Find the ideal effort.

7)At a certain machine an effort of 8N lifts a load of 100 N at an efficiency of 60%. Find the effort and load lost in friction.

Ans 1) Pf=25N 2) Pf=3.19N,Wf=66.64 N. 3) VR=20,EFF=75%

4) Pi=1.5 N,MA=15,VR=20,eff=75% 5) Pi=120 N 6) Pi=97.5 N

7) Pf=3.2N,Wf=66.667 N

Type 3: Problems On law Of Machine

1) Velocity ratio of a machine is 50 and law of machine is P=0.033W+20 N
Find 1) Max MA,2) Max Efficiency 3) Effort to lift a load of 100 N
4) Load that can be lifted by effort of 30 N.

2) Velocity ratio of a machine is 72. The law of machine is P=1/48 W+30 N,
Find the maximum MA, efficiency and state whether machine is reversible.

3) In a lifting machine P=0.1 W+10 ...N. If velocity ratio is 20..Find
1) Max MA,2) Max Efficiency 3) Effort to lift a load of 1 KN
4) Load that can be lifted by effort of 50 N.

4) A machine lifts a load of 400 N by effort of 60 N. It lifts load of 600 N by effort of 80 N. Find law of Machine.

5) In a lifting machine a load of 10 KN is raised by effort of 300 N. It lifts 20 KN by 550 N effort. Find 1) Law of machine 2)Max MA 3) Max efficiency VR=50.

6)Following table shows observations on a certain machine.

Load	Effort
100N	10N
200 N	14 N

Find the law of machine and maximum MA.

7) Following table gives load and effort relation for a simple machine

Load	Effort
1000N	150N
1800 N	200 N

Find the law of machine and Effort to lift load of 5 KN.

Ans 1) Max MA=30.30, Max eff=60.6%,P=23.3 N, W= 303.03

2) Max MA=48, Max eff=66.67%, Reversible machine.

3) Max MA=10, Max eff=50%,P=110 N, W= 400 N

4) P=0.1 W+20 N

5) P=0.025 W+ ,Max MA=40, Max eff=80%

6) P=0.4W+6 N, max MA=25

7) P=0.0625 W+87.5 N, P=400 N.

Type 4 :Problems on Screw jack

1.A screw jack lifts a load of 30 kN has efficiency of 30%, the length of handle is 60 cm. If the pitch of screw is 15 mm. Find the effort required.

2. A screw Jack has effort wheel diameter 200 mm and pitch 5mm. A load of 1000 N is lifted by effort of 150 N. find the efficiency of the screw jack.

3.A screw jack has efficiency of 15%. It lifts a load of 2 kN by effort of 250 N. If length of handle is 60 cm. Find the pitch of the screw.

4. A screw jack lifts a load of 25 kN by an effort of 350 N at the end of a lever arm of 60 cm. If the pitch of the screw is 10 mm. Calculate the efficiency of the screw jack at this load.

5. A screw jack lifts a load of 20kN with an effort of 250 N at the end of lever of arm 50 cm. If the pitch of the screw is 10 mm, calculate the VR,MA and efficiency of the machine. State whether the machine is reversible or not.

Ans: 1) P=397.89 N 2)Eff=5.30% 3)pitch=0.07 m

4) Eff=18.95% 5)eff=25.46%, non reversible.

Type 5 :Problems worm and worm wheel.

1.The following data is related to a double threaded worm and worm wheel

No of teeth on the wheel=60

Diameter of the effort wheel =30 cm

Diameter of the load drum=20 cm.. Calculate VR

2.In a single threaded worm and worm wheel, then number of teeth on the worm wheel is 60. The diameter of the effort wheel is 30 cm and that of load drum is 15 cm. Calculate the velocity ratio. If the efficiency of the machine is a45%, determine the effort required to lift a load of 5kN.

3.In a worm and worm wheel, the number of teeth on the worm are 80. The effort handle is 100 mm and load drum diameter is 400 mm. If the unit is 65%, determine the effort for raising a load of 5kN.

4.A worm and worm wheel carries 50 teeth on wheel, 30 cm effort wheel diameter, 60cm load wheel diameter. If the efficiency is 40%. What load can be lifted with an effort of 30N.

Ans 1) vr=45 2) VR=120,P=92.59 N 3) V.R.=90,M.A.=58.5, p=85.47 N

4) VR=25,MA=10,W=300 N

Type 6:Prob. on Weston's Differential pulley block

1. A Weston's differential pulley block has diameters of pulleys 26 cm and 24 cm. It has efficiency 55%. Find

   1) Effort to lift a load of 5 KN

   2) Effort lost in friction.

2. A Weston's differential pulley block is used to lift load of 8 kN. It has diameters of pulleys 260 mm and 240 mm. If the efficiency of the machine is 45% find the effort required.

3) In a Weston's pulley block the radius of the smaller wheel is ¾ than that of the larger wheel . What load is lifted by the pulley block with an effort of 100 N at an efficiency of 50 %.

4) A Weston's differential pulley block has 12 cogs on the smaller pulley and 13 cogs on the larger pulley. The law of machine is P=W/20+20. Find the efficiency of the machine when a load of 750 N is being lifted.

5) A Weston's differential pulley block has 11 cogs on the bigger pulley and 10 cogs on the smaller pulley. by this machine loads of 400 N and 600N are lifted by efforts of 60 N and 80N respectively. find the law of machine and efficiency of machine at a load of 800 N.

Ans: 1) P= 349.65 N,Pf=157.34 N, 2) P=683.76 N,Wf=9777.76 N

3) W=400N 4) eff=50.16% 5) P=0.1W+20, eff=36.66%

Type 7:Prob. on Simple and differential pulley block

1. In a simple wheel and axle, diameter of wheel is 150 mm and that of axle is 30 mm. If the efficiency of the machine is 60%, determine the effort required to lift a load of 50N.

2.In a differential axle and wheel, the diameter of the wheel is 40 cm and that of axles are 10 cm and 8 cm. If an effort of 50 N can lift a load of 1500 N, Find the efficiency of the machine.

3) In a differential axle and wheel, the diameter of the wheel is 30 Cm and the diameter of the axles are 12 cm and 10 cm. Find efficiency if the machine lifts a load of 1500 N with an effort of 80 N.

4) In a differential axle and wheel, the diameter of wheel is 500 mm and diameters of axle are 120 mm and 100mm. If an effort of 40 N can lift a load of 1200 N, find the efficiency of the machine and effort lost in friction

Ans: 1) P= 16.67 N. 2) eff=75%. 3) eff=66.66%. 4) eff=605, Pf=16 N.

Type 8:Prob. on Single and Double purchase crab

1) A single purchase crab has the following details :

Length of handle =40 cm

Diameter of load drum=20 cm

Number of teeth in the pinion=16

Number of teeth in the spur=80

Find 1) V.R and 2) Effort required to raise the load of 2 KN with an efficiency of 75%.

2)In a double purchase crab, the two pinions 10 teeth each and two spur wheels have 60 teeth each. The diameter of the load drum is 20 cm and that of the effort wheel is 60 cm. Find the velocity ratio.

3) In a double purchase crab, the two pinions have 12 teeth each and the two spur wheels have 72 teeth each. The diameter of the load drum is 22 cm and that of the effort wheel is 65 cm. Find the velocity ratio.

Ans 1) VR=20,p=133.33 N 2) VR=108 3) VR=106.36

Type 9 :Problems on Geared Pulley Block.

1.A geared pulley block is used to lift a load by and effort of 1000 N with 60% efficiency. Calculate the load lifted by the effort if

(i) cogs on effort wheel =100,

(ii) cogs on the load wheel=10

(iii) No of teeth on the pinion =20,

(iv) No of teeth on the spur=40

2.For a geared pulley block, the following data is available

(i) cogs on effort wheel =60,

(ii) cogs on the load wheel=15

(iii) No of teeth on the pinion =10,

(iv) No of teeth on the spur=90

If the max effort required to lift the load is 50 N, calculate the maximum load that cab be lifted by this machine if efficiency is 70%.

Ans 1) W=12 kN 2) W=1.26 kN

ALL Formula's On Simple Machines

Mechanical advantage, Velocity ratio and efficiency of machine

$$Mechanical\ Advantage = M.A. = \frac{Load}{Effort} = \frac{W}{P} \quad .....No\ Unit$$

$$Velocity\ Ratio = \frac{Distance\ Moved\ by\ Effort}{Distance\ Moved\ By\ load} = \frac{y}{x} \quad ..... No\ Unit$$

$$Efficiency = \frac{Output}{Input} = \frac{W \times x}{P \times y} \times 100 \ .....\% \quad Or \quad \eta = \frac{W}{P \times VR} \times 100 .....\%$$

Ideal load,ideal effort,effort lost in friction and load lost in friction

$$Ideal\ Load\ W_i = p \times VR$$

$$Load\ lost\ in\ friction = W_f = P \times V.R. - W$$

$$Ideal\ Effort\ P_i = \frac{w}{VR}$$

$$Effort\ lost\ in\ Friction = P_f = P - \frac{W}{VR}$$

Law of Machine

$$General\ Law\ of\ Machine \quad P = mW + C .....N$$

$$Max\ MA = \frac{1}{m} \qquad Max\ \eta = \frac{Max\ MA}{VR} \times 100$$

Slope of law of machine $m = \frac{P_2 - P_1}{W_2 - W_1}$

Y intercept $P_1 = mW_1 + C$

Condition for reversibility: If $\eta > 50\%$ .....*machine is reversible*

: If $\eta > 50\%$ .....*machine is nonreversible*

Different Machines

Screw Jack $VR = \frac{2\pi L}{P_t}$	Worm and worm $VR = \frac{RT}{nr}$
Westons diff pulley $VR = \frac{2D}{D-d}$	Simple wheel & axle $VR = \frac{D}{d}$
Diff. wheel & axle $VR = \frac{2D}{d_1 - d_2}$	
Single Pur. crab $VR = \frac{l}{r} \times \frac{N_1}{N_2}$	Double Pur crab $VR = \frac{l}{r} \times \frac{N_1}{N_2} \times \frac{N_3}{N_4}$
Geared Pulley Block $VR = \frac{N_1}{N_2} \times \frac{N_3}{N_4}$	