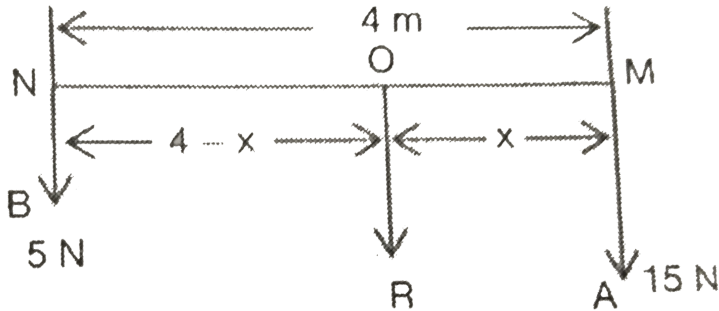# PHYSICS

BOOKS - PEARSON IIT JEE FOUNDATION

SIMPLE MACHINES

Example

1. Two like parallel forces acting on a rod, 15 N and 5 N are separated by a distance of 4 m.
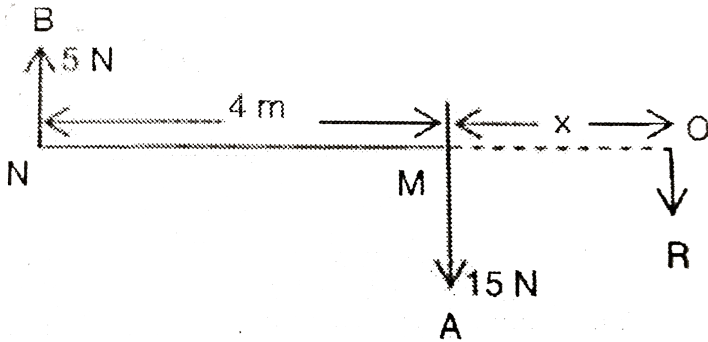
What is the magnitude, direction and point of application of the resultant?

2. Find the magnitude, direction and position of the resultant, if the forces in the above

problem are unlike ?

B
↑5 N
←⋯⋯⋯⋯4 m
N
M
X→O
15 N
A
R

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3. Consider a machine whose mechanical advantage is 5. It raises a load of 25 N. Calculate the minimum effort that has to be applied to it.

A. 5 N

B. 10 N

C. 20 N

D. 25 N

Answer: A

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4. The load arm and effort arm of a lever are 10 cm and 50 cm, respetively. The load and effort are applied on the opposite sides of the

fulcrum. Identify the class of the lever. Find its mechanical advantage. If the effort applied is 10 N, how much load can be raised by it?

5. To lift a piece of burning coal of mass 200 g, a cook uses a fire tong of length 30 cm. He applies the effort at a distance of 10 cm from its fulcrum. Find the effort applied by the cook. $\left(g = 10ms^{-2}\right)$

6. Length of a nut cracker is 25 cm. A nut is kept 8 cm away from the fulcrum and an effort of 32 N is applied at the other end of the nut cracker. Calculate the resistance offered by the nut?

7. A plank of length 4 m is inclined to the ground such that its one end is resting on the ground and the other end is 1 m above ground

level. Calculate the effort that has to be applied to push a load of 48 N up the plank.

8. A force of 8 N is applied to a body at a distance of 20 cm from the point at which it is pivoted. Calculate the torque or moment of force about the pivot.

9. When a force of 10 N is applied about the axis of rotation of a body , it produces a torque of 5 N m. Find the distance of the point of application of the force from the axis of rotation.

10. A mechanic unscrews a nut by applying a force of 120 N on a spanner of length 40 cm.

What should be the required length of the spanner in order to apply only 40 N force ?

11. A heavy metallic scale of length 1 m has its centre of gravity at 50 cm division. It is suspended at a 30 cm mark. A load of $60gwt$ has to be tied at its zero cm make to keep it in equilibrium. Calculate the weight of the scale.

12. A uniform metre scale 1 m long is suspended at 50 cm division. A known weight of 160 gwt is tied at 80 cm division and the scale is balanced by a weight of 240 gwt tied to the scale at a certain distance from the point of suspension on the opposite side. Calculate this distance.

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13. A car has a steering wheel of diameter to cm. It is turned with anti-parallel forces of a

magnitude of 4 N each. Calculate the moment of couple.

14. In a Roman steelyard, the weight of the rider is 25 dyne. When an unknown load is attached 5 cm from the point of suspension, the rider had to be moved by 35 cm. Calculate the unknown load

15. In a wheel and axle, for one complete rotation the magnitude of displacement of effort is 5 times that of the load. What load can be lifted by applying an effort of 10 N? If the radius of the wheel is 35 cm, what is the radius of the axle?

16. The pitch of a screw in a screw jack A is half that of another screw jack B. for 10 complete rotations of the lever, which one of the jack

will lift a car more higher? Which one need more effort to do an equal work if both the jacks have livers of equal length?

Very Short Answer Type Questions

1. State the principle of moments.

2. Give one example of each the three types of levers.

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3. What is the reason for providing a handle to a hand flour grinder at its rim?

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4. Define a lever.

5. What are the factors that help in determining the weight of an object, when measured using a Roman steelyard?

6. A nut cracker is a _____ order lever.

7. What is the M.A. of an inclined plane equal to ?

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8. Define a simple machine.

▶ **Watch Video Solution**

9. Define fulcrum, load arm and effort arm of a lever.

10. What is the principle used in wheel and axle? Mention its applications.

11. What are the types of simple machine?

12. Torque is a _____ quantity.

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13. What is the process of introducing vector into the target bacterial cell known as ?

▶ Watch Video Solution

14. Define parallel forces.

▶ Watch Video Solution

15. Mention the three types of levers.

16. In a screw jack, the work done by an effort

is always _____ that done on its load.

17. Define parallel forces.

18. What is the principle used in the working of

a screw jack?

19. The efficiency of a machine is 50% . If 300 J

of energy is given to the machine, its output is

_____.

20. What is a torque? Mention its C.G.S and S.I. unit.

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21. What are the M.A. of the three types of levers?

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22. How can the mechanical advantage of a screw jack be increased?

23. Explain why a door cannot be opened when force is applied at the hinges.

24. What is the need of along handle for a spanner?

25. What is a torque? Mention its C.G.S and S.I. unit.

26. _____ can transmit motion and power.

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27. When is a body said to be in equilibrium?

Watch Video Solution

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28. What is an inclined plane?

Watch Video Solution

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29. What are gears and where are they used?

Watch Video Solution

30. When can a beam balance have static equilibrium?

Watch Video Solution

Short Answer Type Questions

1. What are the conditions for factors needed for producing a turning effect on a body?

2. Mechanical advantage

3. Give the properties of moment of a couple.

4. Why do we use simple machines?

5. Explain how a couple can produce only rotation.

6. Why do we use simple machines?

7. A sloping plank is used to push goods onto a truck. Its length is 3 m and the end which touches the truck is at a height of 1.5 m. Calculate its M.A. If the effort applied is 25 N, what load can be pushed into the truck?

8. How can the mechanical advantage of a screw jack be increased?

9. Compare like and unlike parallel forces.

10. Length of a crowbar is 150 cm. Its fulcrum is at a distance of 30 cm from the load. What is its mechanical advantage.

11. Explain the basis on which levers are classified.

▶ **Watch Video Solution**

12. Give the advantages of gears.

▶ **Watch Video Solution**

13. What are the M.A. of the three types of levers?

Essay Type Questions

1. What are like and unlike parallel forces? State their characteristics.

2. Describe an inclined plane and obtain an expression for its mechanical advantage.

3. Pulley and wheel and axle

Concept Application Level 1

1. A gear may be used to

2. How can the mechanical advantage of a screw jack be increased?

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3. A wheel and axle can be treated as a modified form of a first order lever.

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4. Moment of force is the product of the force applied on a body and the perpendicular

distance between parallel forces, producing

5. The length of the effort arm is greater than that of the load arm in a second-order lever.

6. Roman steelyard works on the principle of

_____.

7. A pair of scissors is an example of _____ order lever.

8. _____ is the modified form of an inclined plane.

9. Statements: Some gears are wheels

All wheels are brakes

Conclusions: I. No brake is gear

II. Atlest some gears are brakers.

10. To balance a uniform metre scale suspended at 50 cm mark, a with 200 g weight suspended from it at 20 cm mark, a weight of

_____ g must be suspended at 90 cm mark.

11. A road on a hill is an example of _____ .

12. The resultant of two like parallel forces 5 N

and 10 N is _____ N.

Column A		Column B	
A.	S.I. unit of a pair of equal, unlike, parallel, coplanar forces	( ) a.	load ÷ effort
B.	Pliers	( ) b.	third-class lever
C.	Opening screw type lid of a bottle	( ) c.	measuring mass
D.	Resultant of two like parallel forces	( ) d.	N m
E.	Mechanical advantage	( ) e.	second-order lever
F.	Wheel barrow	( ) f.	principle of moments
G.	Efficiency	( ) g.	ratio of radii of wheel to that of axle
H.	C.G.S unit of torque	( ) h.	acts in the same direction as that of the constituent forces
I.	Algebraic sum of moments is zero, in equilibrium	( ) i.	gears
J.	Fire tongs	( ) j.	first order lever
K.	Replacing type of a truck	( ) k.	output / input
L.	Power transmission in vehicles	( ) l.	pulley
M.	M.A. of a wheel and axle	( ) m.	dyne –cm
N.	L = E but makes the effort convenient to apply	( ) n.	screw jack
O.	Roman steel yard	( ) o.	couple

13.

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14. A gear may be used to

A. increase the speed of rotation.

B. increase the torque

C. Both (a) and (b)

D. Neither (a) nor (b)

Answer: C

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15. If the number of teeth in the driven gear of a vehicle is less than that in its driving gear, the vehicle gains _____.

A. speed

B. momentum

C. Both (a) and (b)

D. None of the above

Answer: C

▶ View Text Solution

16. A simple machine

    A. acts as a force multiplier

    B. acts as a speed multiplier

    C. helps to change the direction of

       application of effort

    D. All the above

Answer: D

▶ View Text Solution

17. The efficiency of a rough inclined plane is 90%. The energy spent in raising a load of 225 N through 2 m is

A. 750 N

B. 500 J

C. 850 J

D. 900 J

Answer: B

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18. In a Roman steel yard, the distance of the rider from its zero mark is proportional to the

A. weight of the load.

B. distance of the position of centre of gravity of the steel rod from the fulcrum.

C. distance of point of suspension of the load from the fulcrum.

D. All the above

Answer: A

19. The work done in sliding a wooden box of mass 5 kg along a friction less inclined plane of inclination $30°$ and length 10 m is _____J. $\left(g = 10ms^{-2}\right)$

A. 500

B. 250

C. 125

D. 1500

Answer: B

20. A rod is free to rotate about its mid point. If the clockwise moments of 17 N m and 25 N m, respectively, are acting at the two ends of the rod, then the net moment acting on the rod is

    A. 42 N m , anti-clockwise

    B. 42 N m, clockwise

C. 8 N m, anti-clockwise

D. 8 N m, clockwise

Answer: B

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21. Pulley is the most commonly used simple machine to draw water from a well since

(A) its mechanical advantage is greater than one

(B) it changes the direction of application of effort and makes it convenient to draw water

22. The ratio of load to displacement of the rider from its zero mark in a Roman steel yard is 20 gf:1 cm. If the rider is displaced by 20 cm from its zero mark, the load attached to the steel yard is _____.

A. 40 gf

B. 4 kg

C. 400 gf

D. 0.04 kgf

Answer: C

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23. When the handle of a screwjack is rotated 8 times, the load is raised by 10 cm. If the length of the handle is 0.5 m, the M.A is

A. 40π

B. 20π

C. 120π

D. 80π

Answer: D

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24. M.A. is always greater than 1 in

A. I class levers

B. II class levers

C. III class levers

D. All the above

Answer: B

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25. The length of an inclined plane is halved and the angle of inclination is changed from $30°$ to $60°$. If the work done in pulling a load up the first inclined plane is 'w', then the work

done in pulling the same load up the second

inclined plane is

A. 2w

B. $\dfrac{\sqrt{3}w}{2}$

C. $\dfrac{w}{2}$

D. $\dfrac{2w}{\sqrt{3}}$

Answer: B

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26. The radii of the axle and the wheel are increased by 3 times and 5 times, respectively. The new M.A. advantage of the wheel and axle is

A. $\dfrac{5}{3}$ times the initial M.A

B. $\dfrac{3}{2}$ times the initial M.A.

C. $\dfrac{25}{9}$ times the initial MA

D. $\dfrac{9}{4}$ times the initial M.A.

Answer: B

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27. Two unlike parallel forces 2 N and 16 N act at the ends of a uniform rod of 21 cm length . The point where the resultant of these two act is at a distance of _____ cm from the greater force.

A. 1

B. 2

C. 3

D. 4

Answer: C

28. A wheel and axle with radii 20 cm and 5 cm, respectively, can be considered as

    A. a second-order lever with its M.A. > 1

    B. a third-order lever with its M.A. < 1
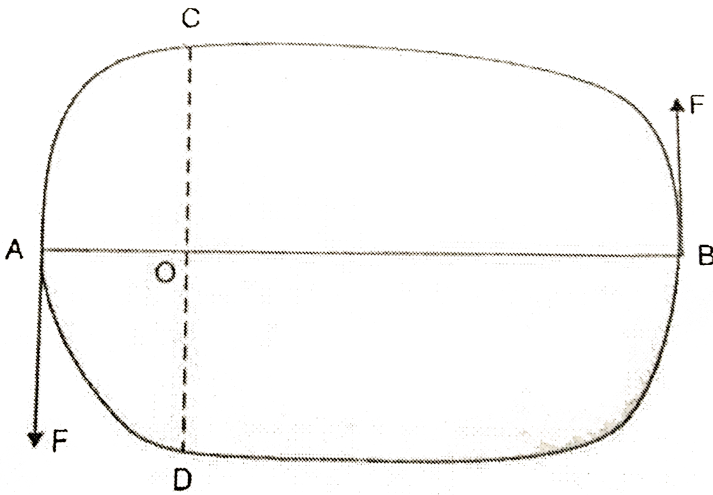
    C. a first-order lever with its M.A. > 1

    D. a first-order lever with its M.A. < 1

Answer: C

29. Two equal forces, F = 30 N act opposite to each other, at points A and B. The distances between various points is as follows.

AO=20cm, OB=50 cm and OC = OD = 25 cm

The body is free to rotate about 'O', in the plane of the paper.

The moment of couple and the moment of the force about 'O' in N m are

A. 21 and 21

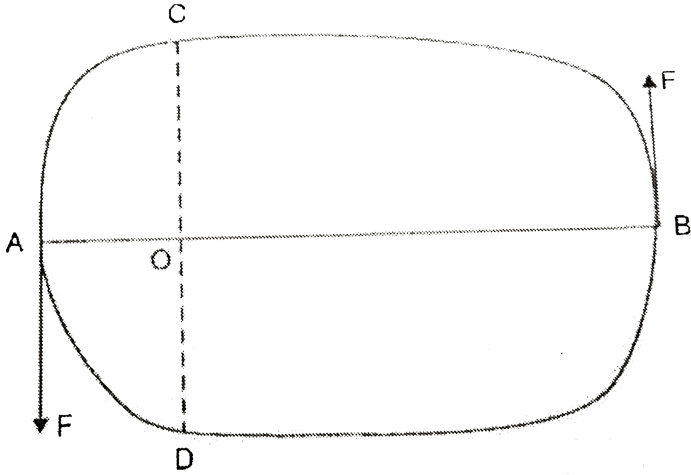B. 21 and 9

C. 31 and 4

D. None of the these

Answer: A

30. Two equal forces, F = 30 N act opposite to each other, at points A and B. The distances between various points is as follows.

AO=20cm, OB=50 cm and OC = OD = 25 cm

The body is free to rotate about 'O', in the plane of the paper.

If the direction of the force at A is reversed, keeping the direction of the force at B unchanged, the moment of the force about 'O' in N m is
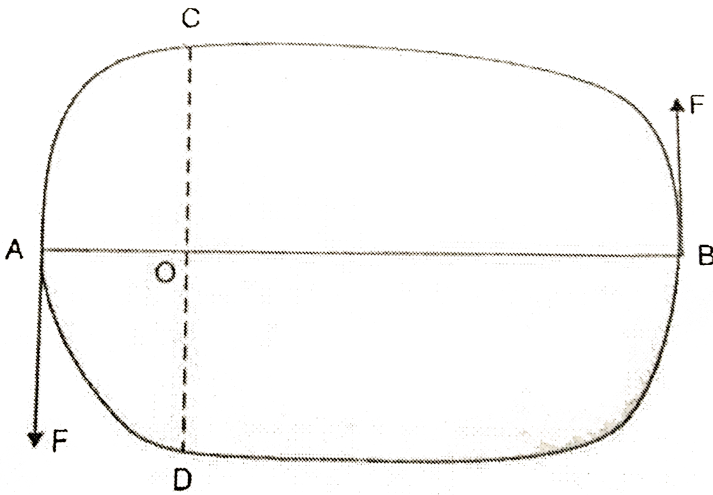
A. 15

B. 6

C. 21

D. 9

Answer: D

31. Two equal forces, F = 30 N act opposite to each other, at points A and B. The distances between various points is as follows.

AO=20cm, OB=50 cm and OC = OD = 25 cm

The body is free to rotate about 'O', in the plane of the paper.

The moment of couple and the moment of the force about 'O' in N m are

A. 21

B. 0

C. 9

D. 6

Answer: B

32. Which of the following physical quantities would complete the analogy given below.

Linear motion: force: rotational motion: _____

    A. work

    B. momentum

    C. torque

    D. angular acceleration

Answer: C

---

33. An effort of 35 N is applied on a machine having mechanical advantage 6. The load that is lifted using the effort is _____ N.

A. 210

B. 41

C. 6

D. 29

Answer: A

34. In a simple machine, the load is displaced by 3 cm corresponding to a displacement of the effort by 300 mm. The velocity ratio of the machine is _____ .

A. 10

B. 270

C. 330

D. 900

Answer: A

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35. The efficiency of a machine is 50% . If 300 J of energy is given to the machine, its output is _____.

A. 150 erg

B. 350 J

C. 250 J

D. 150 J

Answer: D

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36. Which of the following is not true about simple machines? They

A. save energy.

B. can change the direction of the effort.

C. can be used to overcome large force.

D. gain velocity.

Answer: A

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37. The resultant of two like parallel forces 5 N

and 10 N is _____ N.

A. 10

B. 5

C. 15

D. 50

Answer: C

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38. In a second-order lever, if the length of the

load arm is 5 cm, the length of its effort arm

cannot be _____.

A. 4 cm

B. 6 cm

C. 10 cm

D. 20 cm

Answer: A

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39. Roman Numerals

A. no load is placed on the hook.

B. the rider is at the zero of the scale.

C. Both (a) and (b)

D. The beam of a Roman steelyard can never be horizontal.

Answer: C

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40. If the radius of a steering wheel is increased to four times its original value, then the moment of couple acting on the steering wheel for the given forces

A. increase four times.

B. decreases two times.

C. increases eight times.

D. increases sixteen times.

Answer: C

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41. By increasing the angle of inclination, the

M.A. of an inclined plane

A. decreases.

B. increases.

C. remains the same.

D. depends on the load to be raised.

Answer: A

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42. The ratio of load to displacement of the rider from its zero mark in a Roman steel yard is 20 gf:1 cm. If the rider is displaced by 20 cm

from its zero mark, the load attached to the steel yard is _____.

A. 40 gf

B. 4 kgf

C. 400 gf

D. 0.04 kgf

Answer: C

43. If the angle of inclination of an inclined plane of $30°$, its mechanical advantage is

_ _ _ _ _ _

A. 30

B. 43467

C. 2

D. None of the three

Answer: C

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44. An effort of 350 N is applied on an inclined plane having mechanical advantage 6. The load that is lifted using the effort is _____ N.

A. 2100

B. 410

C. 600

D. 329

Answer: A

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1. A uniform metre scale of weight 20 gf is supported on a wedge placed at 60 cm mark. If a weight of 30 gf is suspended at 15 cm mark, where should a weight 200 gf be suspended in order to balance the metre scale?

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2. The efficiency of a simple machine having mechanical advantage 5 is 80% . If the

displacement of the effort in lifting a load by using the machine is 20 cm, find the displacement of the load.
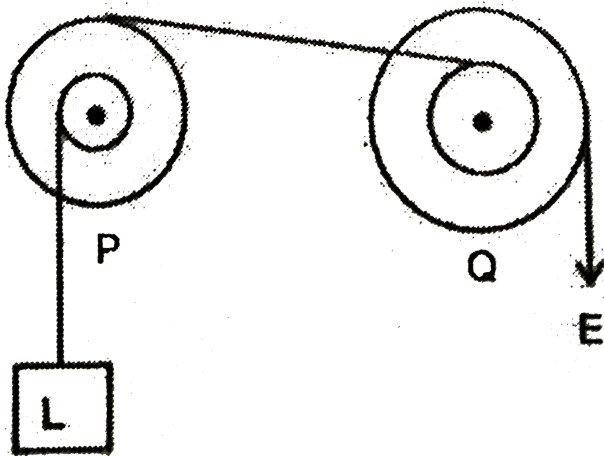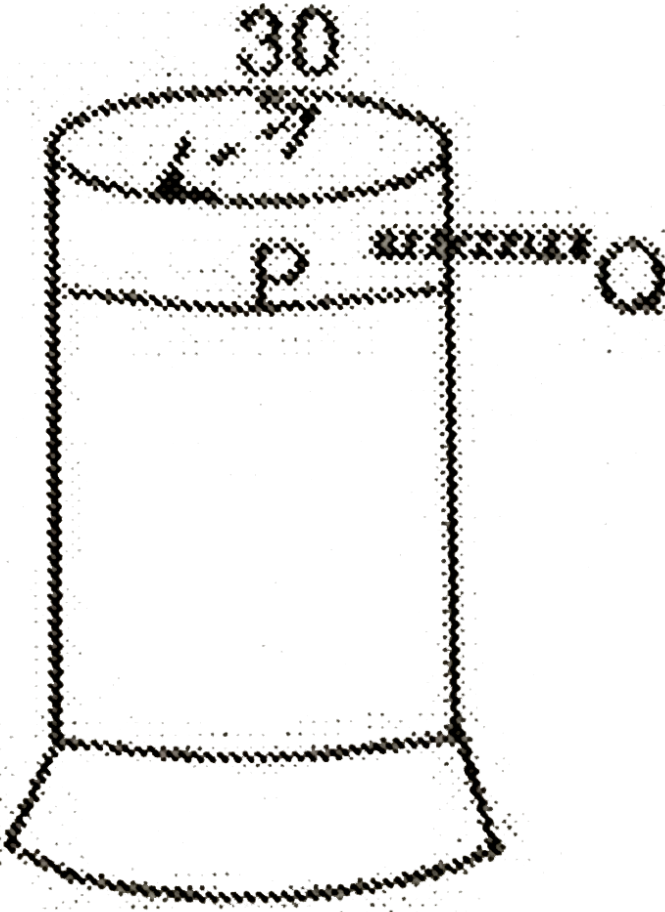
3.

Two wheel and axle systems P and Q are connected as shown in the figure. The radii of

wheels and axles of P and Q are 20 cm, 27 cm, 3 cm and 5 cm, respectively. If L = 540 kgwt, find E.

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4.

The pitch of the screw in a screw jack shown in

the figure is 5 cm and the diameter of the

head of its vertical shaft is 30 cm. If the length

of the rod PQ fixed to the shaft is 55 cm, find the effort required to raise a load of 10.56 quintal using the jack. (Take 1 quintal = 100 kgwt)
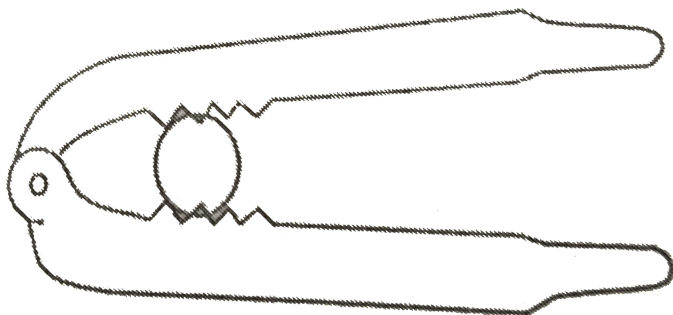
5. On what principle does a bicycle work ? What is the mechanical advantage of a bicycle? Determine the velocity ratio of a bicycle in which the ratio of teeth on the rear

sprocket wheel to that on the front wheel is 1:

3.

6.

The maximum force than can be borne by the

nut placed in a cracker (shown in the figure) is

200 N. The length of the cracker is 20 cm and

the nut is placed at a distance of 15 cm from

the free end of the cracker. If a boy can apply a maximum force of 25 N, find whether he can crack the nut. If not, find the length of the extension rod that should be attached to the cracker handle so that the boy can crack the nut.

7. An inclined plane of length 2 m is used to load Maruti cars into a carrier truck. If the body of the truck is at a height of 1 m from the

ground, find the effort required to load a car using the inclined plane. The unladen weight of a Maruti car is 600 kgwt (Take $g = 10ms^{-2}$)

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8. Why do we use the first gear to start a car or scooter at rest ? What would happen if we started a car/scooter in a higher gear?

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9. To push open a door, a person applies a force of 75 N on the handle of the door, at an angle of $60°$ from the normal to its plane. If the handle is located at a distance of 80 cm from its hinge, find the torque applied by him.

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10. The number of teeth in the crank wheel and free wheel of a bicycle, connected by a chain are 48 and 24, respectively. Their

diameters are 20 cm and 10 cm, respectively. The radius of the rear wheel to which the free wheel is fixed coaxially is 10 times that of the free wheel. If a cyclist pedals the bicycle at two rotations per second, find the speed of the cyclist.

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11. Can a single force applied to a body change both its translational and rotational motion? Explain.

12. Find the ratio of the effort required to raise a given load to a certain height, when the angle of inclination of a plank is changed from $60°$ to $45°$. Also find the lengths of the plank in the two cases given the load has to be raised to a height of 5 m.

13. How can we obtain the resting point-indicating equilibrium, even with unequal masses in the two pans of a physical balance?

14. Each of the two guns, mounted on a rotating platform with their lengths parallel to each other, fires 20 bullets per second at a speed of 50 m s^{-1}. If the perpendicular distance between the two guns is 1.2 m and

the mass of each bullet is 25g, find the couple

acting on the platform.

15. The effort measured in S.I. system in lifting

a load through a simple machine is

numerically equal to its mechanical advantage.

If the mechanical advantage of the machine is

increased by 20%, the same effort can lift a

load of 12 kgwt. Find the magnitudes of the

effort and the original load. (Take $g = 10ms^{-2}$)

16. Why in hand driven grinding machine, handle is put near the circumference of the stone or wheel?

17. To produce a couple of 20 N m on a disc of radius 10 cm, what is the force to be applied.

18. A ladder is kept at rest with is upper end against a wall and the lower end on the ground. The ladder is more like to slip when a mass stands on it at the top than at the bottom. Why ?

19. A uniform metallic rod PQ of length 2 m is acted upon by two forces A and B along the directions as shown in the figure. Find the magnitude and position of the resultant normal force that acts on the rod.

20. A uniform metallic rod AB of length 1.4 m is lifted by two forces P and Q acting along the directions as shown in the figure. If the magnitudes of P and Q are 20 N and 50 N, respectively, find the magnitude and the position of the resultant normal force that acts on the rod.

A (90 N)

60°

P

Q

60°
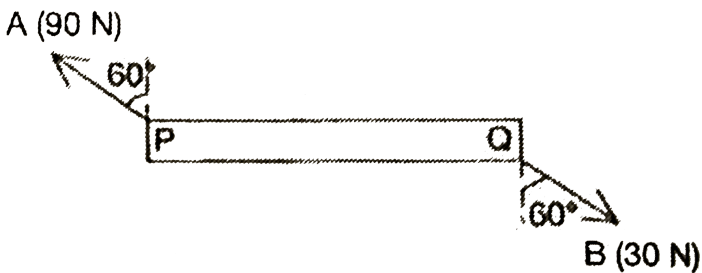
B (30 N)

21. The effort measured in S.I. system in lifting a load through a simple machine is numerically equal to its mechanical advantage. If the mechanical advantage of the machine is increased by 20%, the same effort can lift a load of 12 kgwt. Find the magnitudes of the effort and the original load. (Take $g = 10ms^{-2}$)

22. Find the ratio of efforts required to raise a given load, when the angle of inclination of a given plank is changed from $60°$ to $30°$. Also find the percentage change in the mechanical advantage.

23. A man uses a rough inclined plane of length 3 m to raise a load of 100 kgwt. If he does 2400 J of work and the inclined plane

offers 300 N resistance, find the mechanical advantage (Take $g = 10ms^{-2}$).

24. In an arrangement of two wheel and axle systems, the radii of wheels are 20 cm and 15 cm and the radii of axle are 4 cm and 3 cm. Calculate E if L = 540 kg.

Radius = 20 cm
Radius = 4 cm
Radius= 15 cm
Radius = 3 cm
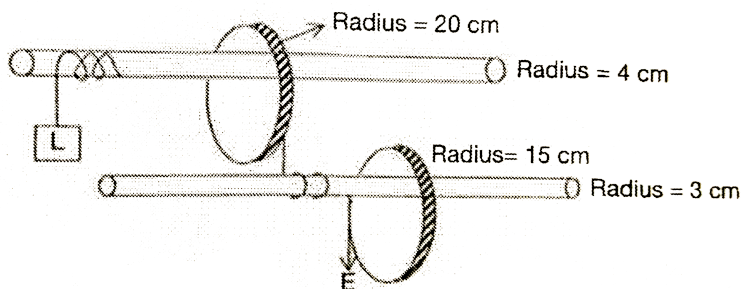
25. The pitch of a screw in a screw jack A is half that of another screw jack B. for 5 complete rotations of the lever, which one of the jack will lift a car more higher? Which one need more effort to do an equal work if both the jacks have livers of equal length.

Level 3

1. A scooter or a motor-cycle is a compound machine made up of several simple machines. Study the following parts of a scooter/motor cycle and identify the simple machines involved in them.

(i) Clutch levers (ii) Throttle

(iii) Front brake lever (iv) Rear brake pedal

(v) Stand (vi) Rear view mirror

(vii) Wheels (viii) Chain drive

A person weighing 50 kg, moves on a scooter of 100 kg at a speed of 36 km h^{-1} and applies brakes to stop within a distance of 10m. If the

mechanical advantage of the brake system (comprising brake drum, lever, etc.) is 10^3, find the force with which the person should press the foot pedal to stop the vehicle.
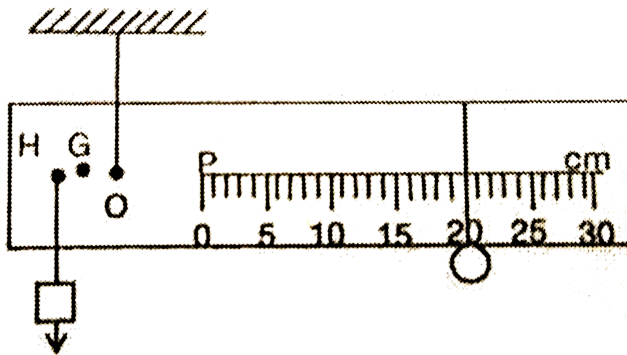
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2. How can a spring balance and a rigid rod be used to weigh objects beyond the maximum reading of the balance? Explain

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3.   300 g$_f$

A balance similar to Roman steelyard is down in the figure. G is the position of centre of gravity in the figure . G is the position of centre of gravity of the beam. Given OG=3 cm, OH =4 cm and OP =5 cm . If the weight of the rider is 60 gf, find the weight of the beam, least count of the balance and the maximum load that can be measured using the balance.
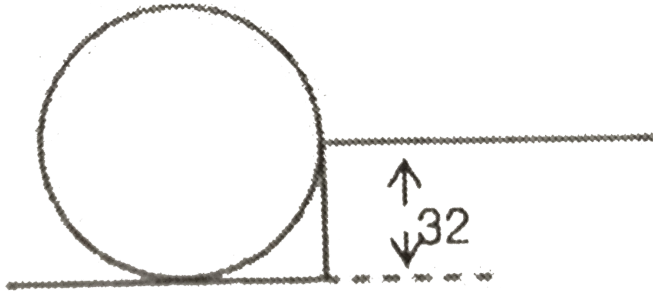
4. A load of 600 kgwt is raised over an inclined plane as shown in the following figure.
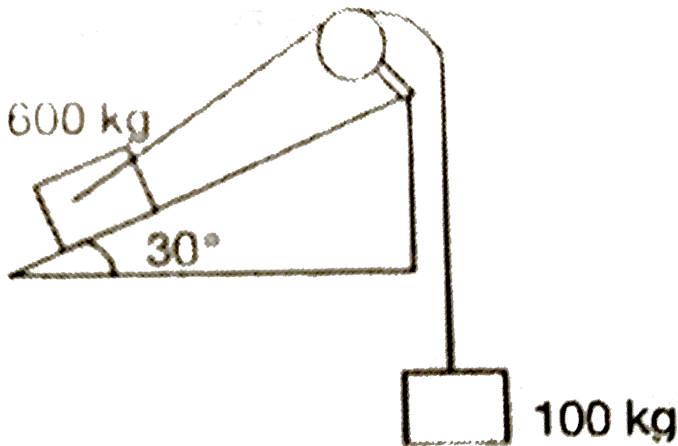
How much force forming a couple should act on the pulley so that the load is just raised?

5.

A solid roller having a diameter of 0.82 m is to be raised on to a step of height 32 cm (shown in the figure). If the roller weights 50 kgwt, find the minimum force that can be applied on the roller for the purpose. (Take$g = 10ms^{-2}$)

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6. A wooden crate with a heavy machine weighing 3000 N slides on the ground when pushed by a lever AB of length 100 cm as shown in the figure. The force required to slide the crate acts at a distance of 10 cm from the fulcrum . If the coefficient of friction between the crate and the ground is $\sqrt{2}$, find the effort required to move the crate. (Take the value of

$\sqrt{2} = 1.4)$

A

45°

B
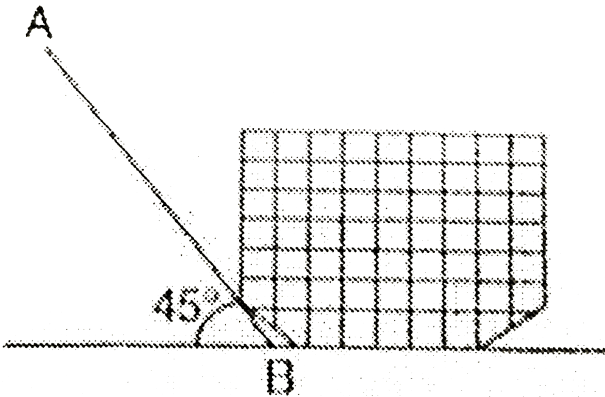
7. A balance similar to a Roman steel yard is constructed such that the length of the scale on the beam of the balance is 50 cm and the least count on the scale is 1 mm. The zero

mark of the scale is at a distance of 15 cm from the point of suspension of the balance. The hook that is used to attach the loads and the centre of gravity of the beam are at distance 8 cm and 5 cm, respectively, from its fulcrum. If the weight of the rider of the balance is 50 gf, find the weight of the beam, the maximum load that can be measured using the balance and its least count.

8. Can a body rotate even if net force acting on it is zero? Can a single force stop a body from rotation, if the body is rotating under the action of a 'couple'? Explain.

9. The length of the beam of a cannot balance shown in the figure is 100 cm. The pans (P and Q) and the strings used to suspend them to the beam in its edges are identical. The hook

(H) that is used to lift the balance is arranged at 50.5 cm from the end of the beam where the pan Q is suspended.
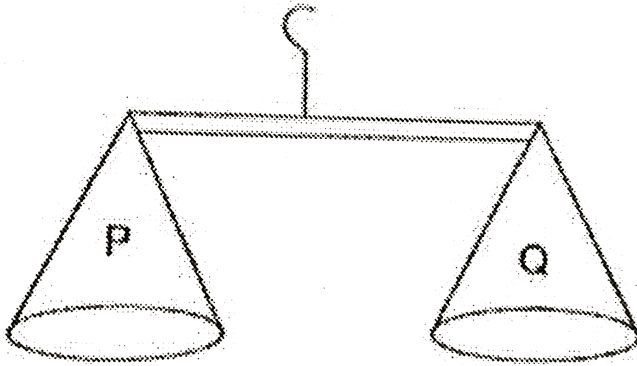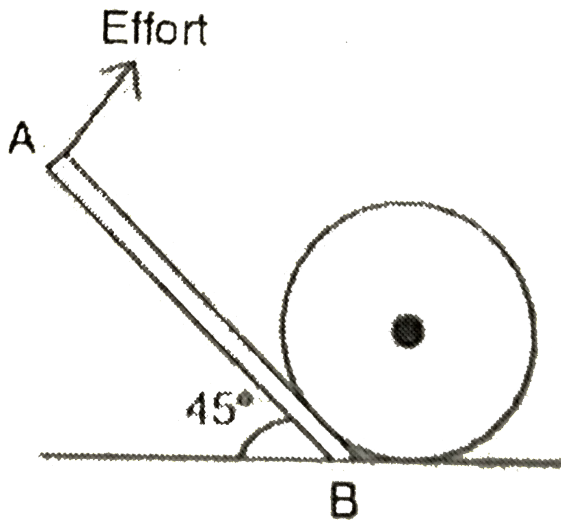

The pan P is used for placing the standard weights. If a customer buys 9 kg of a material using the pan, find the percentage loss in the mass.

10. A road roller of 200 kg wt slides on ground when pushed by a lever AB of length 1m, as shown in the figure. The force required to slide the roller acts at a distance of 5cm from the fulcrum. If the coefficient of friction between the roller and the ground is $\sqrt{2}$ find the effort required to move the roller. (Take

$g = 10ms^{-2})$

Effort

A

45°

B