1. What is the velocity v of a metallic ball of radius r falling in a tank of liquid at the instant when its acceleration is one half that of a freely falling body ? (The densities of metal and of liquid are ρ and σ respectively and the viscosity coefficient of the liquid is η) -

(a) $\frac{r^2 g}{9\eta}(\rho - 2\sigma)$ (b) $\frac{r^2 g}{9\eta}(2\rho - \sigma)$

(c) $\frac{r^2 g}{9\eta}(\rho - \sigma)$ (d) $\frac{2r^2 g}{9\eta}(\rho - \sigma)$

2. Two rain drops reach the earth with their terminal velocities in the ratio 4 : 9. The ratio of their radii is -

(a) 4 : 9 (b) 2 : 3 (c) 3 : 2 (d) 9 : 4

3. Water sticks to glass because of -

(a) Force of cohesion (b) Force of adhesion

(c) Vander wall force (d) None

4. The height of a mercury barometer is 75 *cm* at sea level and 50 *cm* at the top of a hill. Ratio of density of mercury to that of air is 10^4. The height of the hill is

(a) 250 *m* (b) 2.5 *km* (c) 1.25 *km* (d) 750 *m*

5. Two substances of densities ρ_1 and ρ_2 are mixed in equal volume and the relative density of mixture is 4. When they are mixed in equal masses, the relative density of the mixture is 3. The values of ρ_l and ρ_2 are

(a) $\rho_1 = 6$ and $\rho_2 = 2$ (b) $\rho_1 = 3$ and $\rho_2 = 5$

(c) $\rho_1 = 12$ and $\rho_2 = 4$ (d) None of these

6. A silver ingot weighing 2.1 *kg* is held by a string so as to be completely immersed in a liquid of relative density 0.8. The relative density of silver is 10.5. The tension in the string in *kg-wt* is

(a) 1.6 kg-wt (b) 1.94 Kg-wt (c) 3.1 Kg-wt (d) 5.25 kg-wt

7. Two water pipes of diameters 2 *cm* and 4 *cm* are connected with the main supply line. The velocity of flow of water in the pipe of 2 *cm* diameter is

(a) 4 times that in the other pipe

(b) $\frac{1}{4}$ times that in the other pipe

(c) 2 times that in the other pipe

(d) $\frac{1}{2}$ times that in the other pipe

8.

A large open tank has two holes in the wall. One is a square hole of side *L* at a depth *y* from the top and the other is a circular hole of radius *R* at a depth 4*y* from the top. When the tank is completely filled with water the quantities of water flowing out per second from both the holes are the same. Then *R* is equal to

(a) $2\pi L$ (b) $\frac{L}{\sqrt{2\pi}}$ (c) L (d) $\frac{L}{2\pi}$

9. Shape of the meniscus formed by two liquids when capillaries are dipped in in them are shown. In I it is hemispherical whereas in II it is flat. Pick correct statement regarding contact angles formed by the liquids in both situations.

(a) It is 180^0 in I and 90^0 in II

(b) It is 0^0 in land 90^0 in II.

(c) It is 90^0 in I and 0^0 in II

(d) It is greater than 90^0 in I and equal to 90^0 in II.

10. A 45 kg woman is standing on an ice slab without getting her feet wet. What is the minimum volume of the slab?

(a) 0.562 m^3 (b) 0.5 m^3

(c) 0.812 m^3 (d) None of these

11. Two solid spheres of radii r_1 and r_2 have surfaces of same nature and are of same material. Both spheres are at same high temperature 'T'. They are allowed to cool under same conditions. Initial rate of heat loss is -

(a) $\left(\frac{r_2}{r_1}\right)^2$ (b) $\left(\frac{r_1}{r_2}\right)^2$ (c) $\sqrt{\frac{r_1}{r_2}}$ (d) $\sqrt{\frac{r_2}{r_1}}$

12. Two solids A and B float in water. It is observed that A floats with half its volume immersed and B floats with 2/3 of its volume immersed. Compare the densities of A and B

(a) 4 : 3 (b) 2 : 3

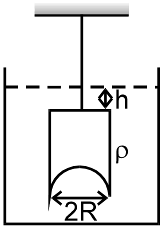
(c) 3 : 4 (d) 1 : 3

13. In order that a floating object be in a stable rotation at equilibrium, its centre of buoyancy should be

(a) vertically above its centre of gravity (b) vertically below its centre of gravity

(c) horizontally in line with its centre of gravity (d) may be anywhere

14. A hemispherical portion of radius R is removed from the bottom of a cylinder of radius R. The volume of the remaining cylinder is V and its mass M. It is suspended by a string in a liquid of density ρ where it stays vertical. The upper surface of the cylinder is at a depth h below the liquid surface. The force on the bottom of the cylinder by the liquid is :



(a) Mg (b) Mg – Vρg

(c) $Mg + \pi R^2 h\rho g$ (d) $\rho g(V + \pi R^2 h)$

15. The bob of a simple pendulum executes simple harmonic motion in water with a period t, while the period of oscillation of the bob is t_0 in air. Neglecting frictional force of water and given that the density of the bob is (4/3) × 1000 kg/m^3. What relationship between t and t_0 is true?

(a) $t = t_0$ (b) $t = t_0/2$

(c) $t = 2t_0$ (d) $t = 4t_0$

16. Two water pipes of diameters 2 cm and 4 cm are connected with the main supply line. The velocity of flow of water in the pipe of 2 cm diameter is

(a) 4 time that in the other pipe (b) $\frac{1}{4}$ time that in the other pipe

(c) 2 time that in the other pipe (d) $\frac{1}{2}$ time that in the other pipe

17. There is a hole in the bottom of tank having water. If total pressure at bottom is 3 atm (1 atm = 10^5 N/m^2) then the velocity of water flowing from hole is

(a) $\sqrt{400}$ m/s (b) $\sqrt{600}$ m/s

(c) $\sqrt{60}$ m/s (d) None of these

18. A streamlined body falls through air from a height h on the surface of a liquid. If d and D(D > d) represents the densities of the material of the body and liquid respectively, then the time after which the body will be instantaneously at rest, is

(a) $\sqrt{\frac{2h}{g}}$ (b) $\sqrt{\frac{2h}{g}.\frac{D}{d}}$

(c) $\sqrt{\frac{2h}{g}.\frac{d}{D}}$ (d) $\sqrt{\frac{2h}{g}}\left(\frac{d}{D-d}\right)$

19. In a turbulent flow, the velocity of the liquid molecules in contact with the walls of the tube is –

(a) Zero (b) Maximum

(c) Equal to critical velocity (d) May have any value

20. A cylinder of height 20m is completely filled with water. The velocity of efflux of water (in ms^{-1}) through a small hole on the side wall of the cylinder near its bottom, is :

(a) 10 (b) 20

(c) 25.5 (d) 5

21. A hole is in the bottom of the tank having water. If total pressure at the bottom is 3 atm (1 atm = 10^5 Nm^{-2}), then velocity of water flowing from hole is :

(a) $\sqrt{400}$ ms^{-1} (b) $\sqrt{600}$ ms^{-1}

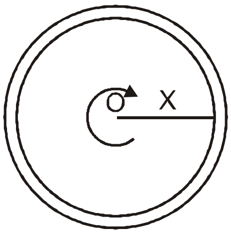
(c) $\sqrt{60}$ ms^{-1} (d) none of these

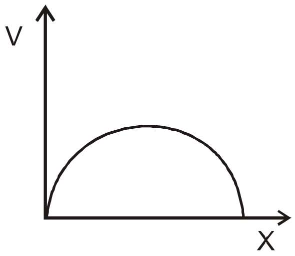
22. A liquid is kept in a cylindrical vessel which is rotated along its axis. The liquid rises at the sides. If the radius of the vessel is 0.05 m and the speed of rotation is 2 rev/s, The difference in the height of the liquid at the centre of the vessel and its sides will be (π^2 = 10) :

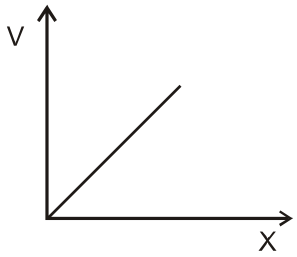
(a) 3 cm (b) 2 cm

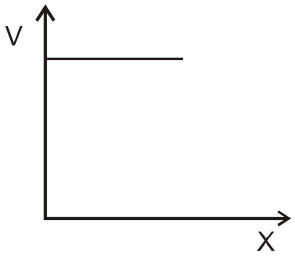
(c) 3/2 cm (d) 2/3 cm

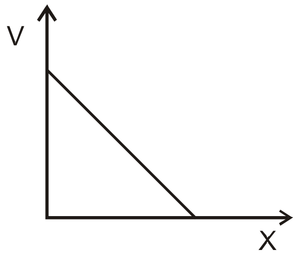
23. The diagram shows a cup of tea seen from above. The tea has been stirred and is now rotating without turbulence. A graph showing the speed υ with which the liquid is crossing points at a distance X from O along a radius XO would look like



(a) 

(b) 

(c) 

(d) 

24. Two non-mixing liquids of densities ρ and $n\rho$ $(n > 1)$ are put in container. The height of each liquid is h. A solid cylinder of length L and density d is put in this container. The cylinder floats with its axis vertical and length pL $(p < 1)$ in the denser liquid. The density d is equal t

(a) $\{1 + (n - 1)p\}\rho$ (b) $\{1 + (n + 1)p\}\rho$

(c) $\{2+(n + 1)p\}\rho$ (d) $\{2 + (n - 1)p\}\rho$

25. A uniform cylinder of length L and mass M having cross - sectional area A is suspended, with its length vertical, from a fixed point by a massless spring such that it is half submerged in a liquid of density σ at equilibrium position. The extension x_0 of the spring when it is in equilibrium is : (Here k is spring constant)

(a) $\frac{Mg}{k}$ (b) $\frac{Mg}{k}\left(1-\frac{LA\sigma}{M}\right)$

(c) $\frac{Mg}{k}\left(1-\frac{LA\sigma}{2M}\right)$ (d) $\frac{Mg}{k}\left(1+\frac{LA\sigma}{M}\right)$

26. A load of mass M kg is suspended from a steel wire of length 2 m and radius 1.0 mm in Searle's apparatus experiment. The increase in length produced in the wire is 4.0 mm. Now the load is fully immersed in a liquid of relative density 2. The relative density of the material of load is 8.

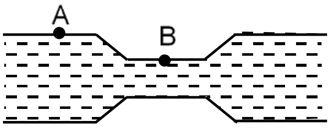
The new value of increase in length of the steel wire is :

(a) 3.0 mm (b) zero

(c) 5.0 mm (d) 4.0 ,,

27. Water flows in a horizontal tube (see figure). The pressure of water changes by 700 Nm^{-2} between A and B where the area of cross section are 40 cm^2 and 20 cm^2, respectively. Find the rate of flow of water through the tube.

(density of water = 1000 kgm^{-3})



(a) 2720 cm^3 /s (b) 2420 cm^3 /s

(c) 3020 cm^3 /s (d) 1810 cm^3 /s

28. An object of mass m is suspended at the end of a massless wire of length L and area of cross-section, A. Young modulus of the material of the wire is Y. If the mass is pulled down slightly its frequency of oscillation along the vertical direction is

(a) $f=\frac{1}{2\pi}\sqrt{\frac{mL}{YA}}$ (b) $f=\frac{1}{2\pi}\sqrt{\frac{YA}{mL}}$

(c) $f=\frac{1}{2\pi}\sqrt{\frac{\mathrm{YL}}{\mathrm{mA}}}$ (d) $f=\frac{1}{2\pi}\sqrt{\frac{mA}{YL}}$

29. A calorimeter of water equivalent 20g contains 180g of water at 25°C. 'm' grams of steam at 100°C is mixed in it till the temperature of the mixture is 31°C. The value of 'm' is close to (Latent heat of water = 540calg^{-1}specific heat of water = 1 cal g^{-1}°C^{-1})

(a) 2 (b) 3.2

(c) 2.6 (d) 4

30. A hydraulic press can lift 100 kg when a mass $'m'$ is placed on the smaller piston. It can lift kg when the diameter of the larger piston is increased by 4 times and that of the smaller piston is decreased by 4 times keeping the same mass $'m'$ on the smaller piston.

1. (c)

$$\eta = \frac{2r^2}{9}\left(\frac{\rho-\sigma}{V}\left(\frac{g}{2}\right)\right)$$

So $V = \dfrac{r^2 g(\rho-\sigma)}{9\eta}$

2. (b)

$v \propto r^2$; $\dfrac{r_1}{r_2} = \sqrt{\dfrac{v_1}{v_2}}$

3. (b)

Adhesive force of attraction act between molecules of different substances.

4. (b)

Difference of pressure between sea level and the top of hill

$\Delta P = (h_1 - h_2)\times \rho_{Hg} \times g = (75-50)\times 10^{-2} \times \rho_{Hg} \times g$ ......(i)

and pressure difference due to h meter of air

$\Delta P = h \times \rho_{air} \times g$ ......(ii)

By equating (i) and (ii) we get

$h \times \rho_{air} \times g = (75-50)\times 10^{-2} \times \rho_{Hg} \times g$

$\therefore h = 25\times 10^{-2}\left(\dfrac{\rho_{Hg}}{\rho_{air}}\right) = 25\times 10^{-2}\times 10^{4} = 2500\ m$

$\therefore$ Height of the hill = 2.5 *km.*

5. (a)

When substances are mixed in equal volume then density

$= \dfrac{\rho_1+\rho_2}{2} = 4 \Rightarrow \rho_1 + \rho_2 = 8$ ....(i)

When substances are mixed in equal masses then density

$= \dfrac{2\rho_1\rho_2}{\rho_1+\rho_2} = 3 \Rightarrow 2\rho_1\rho_2 = 3(\rho_1+\rho_2)$ ....(ii)

By solving (i) and (ii) we get $\rho_1 = 6$ and $\rho_2 = 2$.

6. (b)

Apparent weight $= V(\rho-\sigma)g = \dfrac{M}{\rho}(\rho-\sigma)g = M\left(1-\dfrac{\sigma}{\rho}\right)g$

$= 2.1\left(1-\dfrac{0.8}{10.5}\right)g = 1.94\ g$ *Newton* = 1.94 *Kg-wt*

7. (a)

$d_A = 2\,cm$ and $d_B = 4\ cm$

$\therefore\ r_A = 1\ cm$ and $r_B = 2\ cm$

From equation of continuity *av* = constant

$$\therefore \frac{v_A}{v_B} = \frac{a_B}{a_A} = \frac{\pi(r_B)^2}{\pi(r_A)^2} = \left(\frac{2}{1}\right)^2 \Rightarrow v_A = 4v_B$$

8. (b)

Velocity of efflux when the hole is at depth h, $v = \sqrt{2gh}$

Rate of flow of water from square hole $Q_1 = a_1 v_1 = L^2\sqrt{2gy}$

Rate of flow of water from circular hole

$Q_2 = a_2 v_2 = \pi R^2\sqrt{2g(4y)}$

and according to problem $Q_1 = Q_2$

$\Rightarrow L^2\sqrt{2gy} = \pi R^2\sqrt{2g(4y)} \Rightarrow R = \frac{L}{\sqrt{2\pi}}$

9. (b)

Contact angle is the angle between tangents drawn at contact point, one along solid surface and another along liquid surface. It is measured inside the liquid. In situation l, both tangents are parallel whereas in situation II, they are at 90^0.

10. (a)

0.92 V + 45000 = 1.0 × V

or .08 V = 45000 cc

or V = $\frac{45000}{8} \times 10^2$

= 562.25×10^3 cc

or $0.562\ m^3$

11. (b)

Since ratio of rate of loss of heat is equal to ratio between rate of emission, we have

$$\frac{Q_1}{Q_2} = \frac{\varepsilon_1}{\varepsilon_2} = \frac{eA_1\sigma\theta^4}{eA_2\sigma\theta^4} = \frac{4\pi r_1^2}{4\pi r_2^2} = \left(\frac{r_1}{r_2}\right)^2$$

12. (c)If two different bodies A and B are floating in the same liquid then $\frac{\rho_A}{\rho_B} = \frac{(f_{in})_A}{(f_{in})_B} = \frac{1/2}{2/3} = \frac{3}{4}$

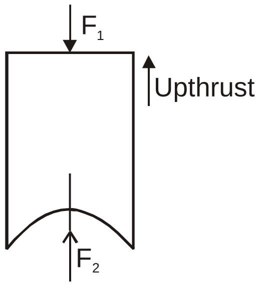
13. (a)If centre of buoyancy is above the centre ofgravity thebody will be in stable equilibrium.

14. (d)[F_{lower} – Fupper] by $_{liquid}$ = Upthrust

$F_2 - F_1$ = upthrust

$\therefore$ $F_2 = F_1$ + upthrust

$F_2 = \rho gh(\pi R^2) + V\rho g$



or $F_2 = \rho g(V + \pi R^2 h)$

In this problem, we did not take the force due to air pressure on the cylinder. This is because force due to air pressure is cancelled. At top and bottom of the cylinder the force due to air pressure is equal and opposite.

15. (c)The time period of simple pendulum in air

$$T = t_0 = 2\pi\sqrt{\left(\frac{\ell}{g}\right)} \qquad \text{...........} \ \textbf{(i)}$$

ℓ, being the length of simple pendulum.

In water, effective weight of bob

w' = weight of bob in air – upthrust

$\Rightarrow \quad \rho V g_{eff} = mg - m'g$

$= \rho V g - \rho' V g = (\rho - \rho')Vg$

where ρ = density of bob,

ρ' = density of water

$$\therefore \quad g_{eff} = \left(\frac{\rho-\rho'}{\rho}\right) g = \left(1-\frac{\rho'}{\rho}\right) g$$

$$\therefore \quad t = 2\pi\sqrt{\left[\left(1-\frac{\rho'}{\rho}\right)g\right]} \qquad \text{..............}\textbf{(ii)}$$

$$\text{Thus vr\%} \qquad \frac{t}{t_0} = \sqrt{\frac{1}{\left[\left(1-\frac{\rho'}{\rho}\right)\right]}} = \sqrt{\left(\frac{1}{1-\frac{1000}{(4/3)\times 1000}}\right)}$$

$$= 2 \Rightarrow t = 2\,t_0$$

16. (a)dA = 2cm and dB = 4cm ∴ rA = 1 cm and rB = 2cm From equation of continuity, $a\nu$= constant

$$\therefore \ \frac{\nu_A}{\nu_B} = \frac{a_B}{a_A} = \frac{\pi(r_B)^2}{\pi(r_A)^2} = \left(\frac{2}{1}\right)^2 \Rightarrow \qquad \nu_A = 4\nu_B$$

17. (a) Pressure at the bottom of tank $P = h\rho g = 3 \times 10^5 \ \frac{N}{m^2}$

Pressure due to liquid column

$$P_1 = 3 \times 10^5 - 1 \times 10^5 = 2 \times 10^5$$

and velocity of water $v = \sqrt{\frac{2p_1}{\rho}} = \sqrt{\frac{2\times 2\times 10^5}{10^3}} = \sqrt{400}$ m/s

18. (d) Upthrust – weight of body = apparent weight

$$VDg - Vdg = Vda,$$

Where a = retardation of body $\therefore\ a = \left(\frac{D-d}{d}\right)g$

The velocity gained after fall from h height in air, $v = \sqrt{2gh}$

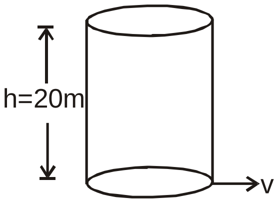
Hence, time to come in rest,

$$t = \frac{v}{a} = \frac{\sqrt{2gh} \times d}{(D-d)g} = \sqrt{\frac{2h}{g}} \times \frac{d}{(D-d)}$$

19. (d)

20. (b) As P.E. = K.E.

$$mgh = \frac{1}{2}mv^2$$



$$v = \sqrt{2gh}$$

$$= \sqrt{2 \times 10 \times 20} \qquad \text{[Here : } g = 10\ m/s^2\text{]}$$

$= 20$ m/s

21. (a)Let height of water column in the tank be h. Total pressure (p) = atmospheric pressure (p_0) + pressure due to water column in tank (p')

$\therefore$ $p' = p - p_0 = 3 - 1 = 2$ atm

or $h\rho g = 2 \times 10^5$

or $h \times 10^3 \times 10 = 2 \times 10^5$

or $h = 20$ m

Hence, velocity of water coming from hole ie, velocity of efflux is

$$v = \sqrt{2gh} = \sqrt{2 \times 10 \times 20}$$

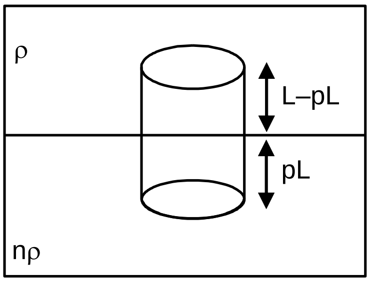
$$= \sqrt{400}\ ms^{-1}$$

22. (b) $y = \frac{\omega^2 r^2}{2y}$

Put values and get y = 2cm.

23. (d) When we move from centre to circumference, the velocity of liquid goes on decreasing and finally becomes zero.

24. **(a)**



wt of body = upthrust by the two liquids

If A = Area of section then

(d A.L) g = [ρA (L - pL) + nρ ApL] g

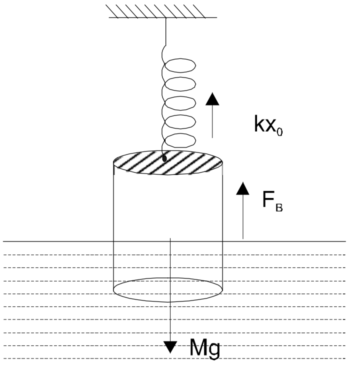
On solving

$\Rightarrow$ d = (1+ (n - 1)p) ρ

25. (c)$kx_0 + F_B = Mg$

$$kx_0 + \sigma \frac{L}{2} Ag = Mg$$

$$x_0 = \frac{Mg - \frac{\sigma LAg}{2}}{k}$$



$$= \frac{Mg}{k}\left(1 - \frac{\sigma LA}{2M}\right)$$

26. (a) $\delta = \frac{\rho_0 Vg \times L}{Ay}$

$$\delta' = \frac{(\rho_0 - \rho_L)vg \times L}{Ay}$$

$$\Rightarrow \frac{\delta'}{\delta} = \frac{\rho_0 - \rho_L}{\rho_0} = \frac{8-2}{8}$$

δ' = 3 mm

27. (a) using equation of continuity

$$40 V_A = 20 V_B$$

28. $2V_A = V_B$

Using Bernoullies equation

$$P_A + \frac{1}{2}\rho V_A^2 = P_B + \frac{1}{2}\rho V_B^2$$

$$\Rightarrow \quad P_A - P_B = \frac{1}{2}\rho(V_B^2 - V_A^2)$$

$$\Rightarrow \quad \Delta P = \frac{1}{2}1000\left(V_B^2 - \frac{V_B^2}{4}\right)$$

$$\Rightarrow \quad \Delta P = 500 \times \frac{3V_B^2}{4}$$

$$\Rightarrow \quad V_B = \sqrt{\frac{(\Delta P)\times 4}{1500}} = \sqrt{\frac{(700)\times 4}{1500}} \text{ m/s}$$

Volume flow rate = $20 \times 100 \times V_B = 2732$ cm^3/s

29. **(b)JEE Main 2020**

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

$$k = \frac{YA}{L}$$

$$f = \left(\frac{1}{2\pi}\right)\sqrt{\frac{YA}{mL}}$$

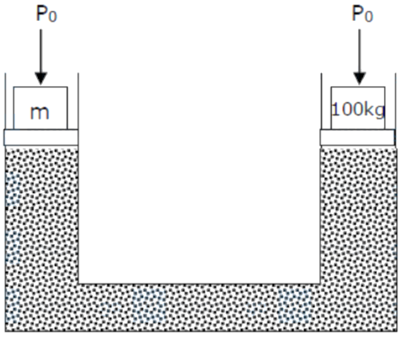
30. **(a)JEE Main 2020**

$$\mathrm{m}[540 + (100 - 31)] = 200 \times [31 - 25]$$

$$\mathrm{m} = \frac{1200}{609}$$

$$\simeq 2\mathrm{gm}$$

31. 25600 **JEE Main 2021**



Atmospheric pressure P_0 will be acting on both the limbs of hydraulic lift.
Applying pascal's law for same liquid level

$$\Rightarrow P_0 + \frac{mg}{A_1} = P_0 + \frac{(100)g}{A_2}$$

$$\Rightarrow \frac{Mg}{A_1} = \frac{(100)g}{A_2}$$

$$\Rightarrow \frac{m}{100} = \frac{A_1}{A_2} \ldots \text{(i)}$$

Diameter of piston on side of 100kg is increased by 4 times so new area = $16A_2$
Diameter of piston on side of (m)kg is decreasing

$$A_1 = \frac{A_1}{16}$$

(In order to increasing weight lifting capacity, diameter of smaller piston must be reduced)

Again, $\frac{mg}{\left(\frac{A_1}{16}\right)} = \frac{M'g}{16A_2} \Rightarrow \frac{256m}{M'} = \frac{A_1}{A_2}$

From equation(1) $= \frac{256\mathrm{m}}{\mathrm{M}'} = \frac{\mathrm{m}}{100}$

$$\Rightarrow \therefore \mathrm{M}' = 25600\mathrm{kg}$$