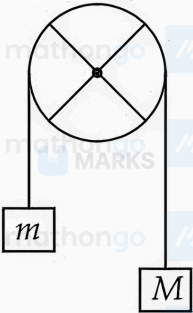


Q1. JEE Main 2026 (21 January Shift 2)

The pulley shown in figure is made using a thin rim and two rods of length equal to diameter of the rim. The rim and each rod have a mass of M . Two blocks of mass of M and m are attached to two ends of a light string passing over the pulley, which is hinged to rotate freely in vertical plane about its center. The magnitudes of the acceleration experienced by the blocks is ____ (assume no slipping of string on pulley).



- (1) $\frac{(M-m)g}{[(\frac{13}{6})M+m]}$ (2) $\frac{(M-m)g}{[(\frac{8}{3})M+m]}$ (3) $\frac{(M-m)g}{2M+m}$ (4) $\frac{(M-m)g}{M+m}$

Q2. JEE Main 2026 (21 January Shift 2)

Two cars A and B each of mass 10^3 kg are moving on parallel tracks separated by a distance of 10 m, in same direction with speeds 72 km/h and 36 km/h. The magnitude of angular momentum of car A with respect to car B is ____ J.s.

- (1) 2×10^5 (2) 10^5
(3) 3.6×10^5 (4) 3×10^5

Q3. JEE Main 2026 (23 January Shift 1)

Two small balls with masses m and $2m$ are attached to both ends of a rigid rod of length d and negligible mass. If angular momentum of this system is L about an axis (A) passing through its centre of mass and perpendicular to the rod then angular velocity of the system about A is :

- (1) $\frac{2L}{5md^2}$ (2) $\frac{4}{3} \frac{L}{md^2}$ (3) $\frac{3}{2} \frac{L}{md^2}$ (4) $\frac{2L}{md^2}$

Q4. JEE Main 2026 (23 January Shift 1)

The moment of inertia of a square loop made of four uniform solid cylinders, each having radius R and length L ($R < L$) about an axis passing through the mid points of opposite sides, is (Take the mass of the entire loop as M)

- (1) $\frac{3}{4}MR^2 + \frac{7}{12}ML^2$ (2) $\frac{3}{8}MR^2 + \frac{1}{6}ML^2$
(3) $\frac{3}{4}MR^2 + \frac{1}{6}ML^2$ (4) $\frac{3}{8}MR^2 + \frac{7}{12}ML^2$

Q5. JEE Main 2026 (28 January Shift 2)

When the position vector $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$ changes sign as $-\vec{r}$, which one of the following vector will not flip under sign change ?

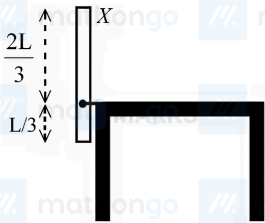
- (1) Angular momentum (2) Velocity
 (3) Acceleration // mathongo // mathongo //(4) Linear momentum

Q6. JEE Main 2026 (28 January Shift 2)

A fly wheel having mass 3 kg and radius 5 m is free to rotate about a horizontal axis. A string having negligible mass is wound around the wheel and the loose end of the string is connected to 3 kg mass. The mass is kept at rest initially and released. Kinetic energy of the wheel when the mass descends by 3 m is ____ J. ($g = 10 \text{ m/s}^2$)

Q7. JEE Main 2026 (24 January Shift 2)

A thin uniform rod (X) of mass M and length L is pivoted at a height $(\frac{L}{3})$ as shown in the figure. The rod is allowed to fall from a vertical position and lie horizontally on the table. The angular velocity of this rod when it hits the table top, is _____. (g = gravitational acceleration)



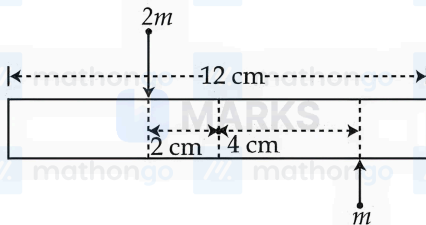
- $$(1) \frac{3}{\sqrt{2}} \sqrt{\frac{g}{L}} \quad (2) \frac{1}{\sqrt{2}} \sqrt{\frac{g}{L}} \quad (3) \sqrt{\frac{3}{2} \frac{g}{L}} \quad (4) \sqrt{\frac{3g}{L}}$$

Q8. JEE Main 2026 (24 January Shift 2)

A uniform solid cylinder of length L and radius R has moment of inertia about its axis equal to I_1 . A small co-centric cylinder of length $L/2$ and radius $R/3$ carved from this cylinder has moment of inertia about its axis equals to I_2 . The ratio I_1/I_2 is ____.

Q9. JEE Main 2026 (22 January Shift 2)

A uniform bar of length 12 cm and mass $20m$ lies on a smooth horizontal table. Two point masses m and $2m$ are moving in opposite directions with same speed of v and in the same plane as the bar, as shown in figure. These masses strike the bar simultaneously and get stuck to it. After collision the entire system is rotating with angular frequency ω . The ratio of v and ω is :



- (1) 66 (2) 33 (3) 32 (4) $2\sqrt{88}$

Q10. JEE Main 2026 (22 January Shift 2)

Two masses m and $2m$ are connected by a light string going over a pulley (disc) of mass $30m$ with radius $r = 0.1$ m. The pulley is mounted in a vertical plane and it is free to rotate about its axis. The $2m$ mass is released from rest and its speed when it has descended through a height of 3.6 m is _____ m/s. (Assume string does not slip and $g = 10$ m/s²)

Q11. JEE Main 2026 (22 January Shift 1)

A solid sphere of mass 5 kg and radius 10 cm is kept in contact with another solid sphere of mass 10 kg and radius 20 cm. The moment of inertia of this pair of spheres about the tangent passing through the point of contact is _____ kg.m².

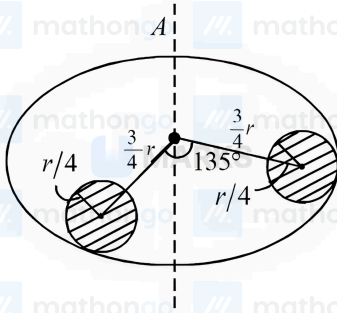
- (1) 0.72 (2) 0.36 (3) 0.18 (4) 0.63

Q12. JEE Main 2026 (22 January Shift 1)

A circular disc has radius R_1 and thickness T_1 . Another circular disc made of the same material has radius R_2 and thickness T_2 . If the moment of inertia of both discs are same and $\frac{R_1}{R_2} = 2$ then $\frac{T_1}{T_2} = \frac{1}{\alpha}$. The value of α is _____.

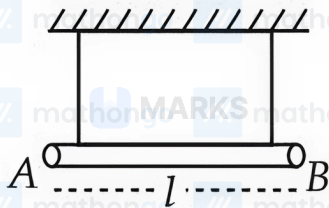
Q13. JEE Main 2026 (23 January Shift 2)

Suppose there is a uniform circular disc of mass M kg and radius r m shown in figure. The shaded regions are cut out from the disc. The moment of inertia of the remainder about the axis A of the disc is given by $\frac{x}{256}Mr^2$. The value of x is _____.



Q14. JEE Main 2026 (21 January Shift 1)

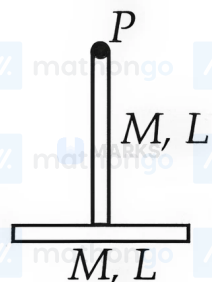
A uniform rod of mass m and length l suspended by means of two identical inextensible light strings as shown in figure. Tension in one string immediately after the other string is cut, is _____. (g acceleration due to gravity)



- (1) $mg/4$ (2) $mg/2$ (3) $mg/3$ (4) mg

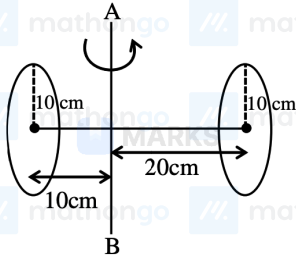
Q15. JEE Main 2026 (21 January Shift 1)

Two identical thin rods of mass M kg and length L m are connected as shown in figure. Moment of inertia of the combined rod system about an axis passing through point P and perpendicular to the plane of the rods is $\frac{x}{12}ML^2$ kg m². The value of x is _____.



Q16. JEE Main 2026 (28 January Shift 1)

Two circular discs of radius each 10 cm are joined at their centres by a rod of length 30 cm and mass 600 gm as shown in figure. If the mass of each disc is 600 gm and applied torque between two discs is 43×10^5 dyne. cm, the angular acceleration of the discs about the given axis AB is ____ rad/s².



- (1) 11 (2) 22 (3) 100 (4) 27

Q17. JEE Main 2026 (28 January Shift 1)

A solid sphere of radius 10 cm is rotating about an axis which is at a distance 15 cm from its centre. The radius of gyration about this axis is $\sqrt{n}$ cm. The value of n is

Q18. JEE Main 2026 (24 January Shift 1)

Two masses 400 g and 350 g are suspended from the ends of a light string passing over a heavy pulley of radius 2 cm. When released from rest the heavier mass is observed to fall 81 cm in 9 s. The rotational inertia of the pulley is ____ kg · m². ($g = 9.8$ m/s²)

- (1) 4.75×10^{-3} (2) 9.5×10^{-3}
 (3) 1.86×10^{-2} (4) 8.3×10^{-3}

ANSWERS AND SOLUTIONS

1. (2) 2. (2) 3. (3) 4. (2) 5. (1) 6. 30 7. (4) 8. 162
9. (2) 10. 2 11. (4) 12. 16 13. 109 14. (1) 15. 17 16. (1)
17. 265 18. (2)

1. (2) The pulley consists of a rim (mass M) and two rods (each mass M) forming a diameter structure.

The moment of inertia is: $I = I_{rim} + I_{rods} = MR^2 + 2 \times \frac{MR^2}{3} = \frac{5MR^2}{3}$.

For the Atwood pulley system, applying Newton's second law:

Mass m (upward): $T_1 = m(g - a)$

Mass M (downward): $T_2 = M(g + a)$

Pulley rotation: $T_2R - T_1R = I\alpha = \frac{5MR^2}{3} \cdot \frac{a}{R}$

Thus: $T_2 - T_1 = \frac{5Ma}{3}$

Substituting: $M(g + a) - m(g - a) = \frac{5Ma}{3}$

$(M - m)g + (M + m)a = \frac{5Ma}{3}$

$(M - m)g = a \left(\frac{5M}{3} - M - m \right) = a \left(\frac{2M}{3} - m \right)$

$a = \frac{(M - m)g}{\frac{2M - 3m}{3}} = \frac{3(M - m)g}{2M + 3m}$, which is option (2).

2. (2) Mass of each car $m = 10^3$ kg.

Speed of car A, $v_A = 72$ km/h $= 72 \times \frac{5}{18} = 20$ m/s.

Speed of car B, $v_B = 36$ km/h $= 36 \times \frac{5}{18} = 10$ m/s.

Relative velocity of car A with respect to car B is $v_{AB} = v_A - v_B = 20 - 10 = 10$ m/s.

The cars are moving on parallel tracks separated by a perpendicular distance $d = 10$ m.

The magnitude of angular momentum of car A with respect to car B is given by $L = m \times v_{AB} \times d$.

Substituting the values: $L = 10^3 \times 10 \times 10 = 10^5$ J.s.

Thus, the correct option is (2).

3. (3) CM from mass m : $x_{cm} = \frac{2md}{3m} = \frac{2d}{3}$.

Distances: m is $2d/3$ from CM, $2m$ is $d/3$ from CM.

$I_{cm} = m(2d/3)^2 + 2m(d/3)^2 = \frac{4md^2}{9} + \frac{2md^2}{9} = \frac{2md^2}{3}$.

$L = I\omega \Rightarrow \omega = \frac{L}{I} = \frac{3L}{2md^2}$.

4. (2) Each cylinder has mass $M/4$, radius R , length L .

Axis through midpoints of top and bottom sides (along y-direction).

Top/bottom cylinders (perpendicular to axis, axis through midpoint):

$I = \frac{M_c R^2}{4} + \frac{M_c L^2}{12}$ each.

Left/right cylinders (parallel to axis, distance $L/2$ from it):

$I = \frac{M_c R^2}{2} + M_c (L/2)^2$ each.

$$\begin{aligned} \text{Total} &= 2 \left(\frac{M_c R^2}{4} + \frac{M_c L^2}{12} \right) + 2 \left(\frac{M_c R^2}{2} + \frac{M_c L^2}{4} \right) \\ &= \frac{M}{2} \left(\frac{3R^2}{4} + \frac{L^2}{3} \right) = \frac{3MR^2}{8} + \frac{ML^2}{6}. \end{aligned}$$

5. (1) The transformation $\vec{r} \rightarrow -\vec{r}$ is known as a parity transformation (inversion through the origin).

Vectors that change sign under parity are called polar vectors, while those that do not change sign are called axial vectors (or pseudovectors).

Velocity is defined as $\vec{v} = \frac{d\vec{r}}{dt}$. Since $\vec{r} \rightarrow -\vec{r}$, we have $\vec{v} \rightarrow -\vec{v}$.

Acceleration is defined as $\vec{a} = \frac{d\vec{v}}{dt}$. Since $\vec{v} \rightarrow -\vec{v}$, we have $\vec{a} \rightarrow -\vec{a}$.

Linear momentum is defined as $\vec{p} = m\vec{v}$. Since $\vec{v} \rightarrow -\vec{v}$, we have $\vec{p} \rightarrow -\vec{p}$.

Angular momentum is defined as $\vec{L} = \vec{r} \times \vec{p}$.

Under the transformation $\vec{r} \rightarrow -\vec{r}$ and $\vec{p} \rightarrow -\vec{p}$, the cross product becomes:

$$\vec{L}' = (-\vec{r}) \times (-\vec{p}) = \vec{r} \times \vec{p} = \vec{L}.$$

Thus, angular momentum does not flip its sign under the transformation $\vec{r} \rightarrow -\vec{r}$.

6. (30) Let the mass of the flywheel be $M = 3$ kg and its radius be $R = 5$ m.

Let the hanging mass be $m = 3$ kg and the distance descended be $h = 3$ m.

The flywheel is a disk, so its moment of inertia is $I = \frac{1}{2}MR^2$.

By conservation of energy, the loss in potential energy of the hanging mass equals the gain in kinetic energy of the system.

$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

Since the string does not slip, $v = R\omega$, so $\omega = \frac{v}{R}$.

$$mgh = \frac{1}{2}mv^2 + \frac{1}{2} \left(\frac{1}{2}MR^2 \right) \left(\frac{v}{R} \right)^2$$

$$mgh = \frac{1}{2}mv^2 + \frac{1}{4}Mv^2$$

Substituting the values: $3 \times 10 \times 3 = \frac{1}{2}(3)v^2 + \frac{1}{4}(3)v^2$

$$90 = \frac{3}{2}v^2 + \frac{3}{4}v^2 = \frac{9}{4}v^2$$

$$v^2 = \frac{90 \times 4}{9} = 40 \text{ m}^2/\text{s}^2.$$

The kinetic energy of the wheel is $K_{\text{wheel}} = \frac{1}{2}I\omega^2 = \frac{1}{4}Mv^2$.

$$K_{\text{wheel}} = \frac{1}{4} \times 3 \times 40 = 30 \text{ J}.$$

7. (4) The rod is pivoted at a distance $\frac{L}{3}$ from one end. The centre of mass is at a distance $\frac{L}{6}$ from the pivot.

Using energy conservation:

$$mg\frac{\ell}{6} = \frac{1}{2}I\omega^2$$

Moment of inertia about the pivot (using parallel axis theorem):

$$I = \frac{m\ell^2}{12} + m \left(\frac{\ell}{6} \right)^2 = \frac{m\ell^2}{12} + \frac{m\ell^2}{36} = \frac{m\ell^2}{9}$$

$$mg\frac{\ell}{6} = \frac{1}{2} \cdot \frac{m\ell^2}{9} \cdot \omega^2$$

$$\omega^2 = \frac{9g}{6 \cdot \frac{\ell}{2}} = \frac{3g}{\ell}$$

$$\omega = \sqrt{\frac{3g}{\ell}}$$

8. (162) For solid cylinder: $I = \frac{1}{2}mR^2$

Large cylinder: mass $m_1 = \rho\pi R^2 L$, so $I_1 = \frac{1}{2}\rho\pi R^2 L \times R^2 = \frac{\rho\pi R^4 L}{2}$

Small cylinder (carved out): length $L/2$, radius $R/3$, mass $m_2 = \rho\pi(R/3)^2(L/2) = \frac{\rho\pi R^2 L}{18}$

$I_2 = \frac{1}{2} \times \frac{\rho\pi R^2 L}{18} \times (R/3)^2 = \frac{1}{2} \times \frac{\rho\pi R^2 L}{18} \times \frac{R^2}{9} = \frac{\rho\pi R^4 L}{324}$

$\frac{I_1}{I_2} = \frac{\rho\pi R^4 L/2}{\rho\pi R^4 L/324} = \frac{324}{2} = 162$

9. (2) Linear momentum conservation: $mv - 2mv = 23m \cdot v_{cm}$, giving $v_{cm} = -\frac{v}{23}$.

Angular momentum about center of mass from the collision geometry:

Taking collision points 2 cm and 4 cm from the 12 cm bar's center at different positions, the angular momentum is

$L = m \cdot v \cdot r_1 + (-2m) \cdot v \cdot r_2$.

Calculating moment of inertia: $I = \frac{1}{12}(20m)(0.12)^2 + m(0.02)^2 + 2m(0.04)^2 = 0.0276m$

The angular frequency ω is obtained from $\omega = \frac{L}{I}$, giving ratio $\frac{v}{\omega} = 33$.

10. (2) Let the speed of the masses be v and the angular velocity of the pulley be $\omega = v/r$ since the string does not slip.

The pulley is a disc of mass $M = 30m$ and radius r . Its moment of inertia is $I = \frac{1}{2}Mr^2 = \frac{1}{2}(30m)r^2 = 15mr^2$.

Using the principle of conservation of mechanical energy, the loss in potential energy of the system equals the gain in kinetic energy.

When the mass $2m$ descends by $h = 3.6$ m, the mass m ascends by $h = 3.6$ m.

Loss in potential energy $\Delta U = (2m)gh - (m)gh = mgh$.

Gain in kinetic energy $\Delta K = \frac{1}{2}(2m)v^2 + \frac{1}{2}(m)v^2 + \frac{1}{2}I\omega^2$.

Substituting I and ω : $\Delta K = \frac{3}{2}mv^2 + \frac{1}{2}(15mr^2)(\frac{v}{r})^2 = \frac{3}{2}mv^2 + \frac{15}{2}mv^2 = 9mv^2$.

Equating $\Delta U = \Delta K$: $mgh = 9mv^2$.

$v^2 = \frac{gh}{9}$.

Given $g = 10$ m/s² and $h = 3.6$ m:

$v^2 = \frac{10 \times 3.6}{9} = \frac{36}{9} = 4$.

$v = \sqrt{4} = 2$ m/s.

11. (4) For two solid spheres in contact with the tangent line at the contact point.

Sphere 1: $m_1 = 5$ kg, $r_1 = 0.1$ m

Sphere 2: $m_2 = 10$ kg, $r_2 = 0.2$ m

For a solid sphere, $I_{cm} = \frac{2}{5}mr^2$

The tangent at contact is perpendicular to the line joining centers. The perpendicular distance from each sphere's center to this tangent line equals its radius.

Using parallel axis theorem: $I_{total} = I_{cm} + md^2$

For sphere 1: $I_1 = \frac{2}{5}(5)(0.1)^2 + 5(0.1)^2 = 0.02 + 0.05 = 0.07$ kg·m²

For sphere 2: $I_2 = \frac{2}{5}(10)(0.2)^2 + 10(0.2)^2 = 0.16 + 0.4 = 0.56$ kg·m²

Total: $I = 0.07 + 0.56 = 0.63$ kg·m²

12. (16) For a circular disc made of material with density ρ , moment of inertia is

$$I = \frac{1}{2}MR^2 = \frac{1}{2}\rho\pi R^2T \cdot R^2 = \frac{1}{2}\rho\pi R^4T.$$

$$\text{For disc 1: } I_1 = \frac{1}{2}\rho\pi R_1^4T_1$$

$$\text{For disc 2: } I_2 = \frac{1}{2}\rho\pi R_2^4T_2$$

$$\text{Given } I_1 = I_2:$$

$$R_1^4T_1 = R_2^4T_2$$

$$\text{With } \frac{R_1}{R_2} = 2:$$

$$(2R_2)^4T_1 = R_2^4T_2$$

$$16R_2^4T_1 = R_2^4T_2$$

$$\frac{T_1}{T_2} = \frac{1}{16}$$

$$\text{Therefore } \alpha = 16.$$

13. (109) The moment of inertia of the complete disc about axis A is

$$I_{disc} = \frac{1}{2}Mr^2 = \frac{128Mr^2}{256}.$$

$$\text{Each removed circular region has radius } r/4 \text{ and mass } m_i = M/(r^2/16r^2) = M/16.$$

For each removed disc at distance $3r/4$ from axis A, using the parallel axis theorem:

$$I_{removed} = \frac{1}{2}m_i(r/4)^2 + m_i(3r/4)^2 = \frac{Mr^2}{512} + \frac{9Mr^2}{256} = \frac{19Mr^2}{512}.$$

For two removed discs:

$$I_{2removed} = \frac{38Mr^2}{512} = \frac{19Mr^2}{256}.$$

Therefore:

$$I_{remainder} = \frac{128Mr^2}{256} - \frac{19Mr^2}{256} = \frac{109Mr^2}{256}, \text{ so } x = 109.$$

14. (1) When string at B is cut, rod rotates about A.

$$\text{Torque about A: } \tau = mg \times \frac{l}{2}$$

$$\text{Moment of inertia about A: } I_A = \frac{ml^2}{3}$$

$$\text{Angular acceleration: } \alpha = \frac{mg \cdot l/2}{ml^2/3} = \frac{3g}{2l}$$

$$\text{Acceleration of COM: } a_{cm} = \alpha \times \frac{l}{2} = \frac{3g}{4}$$

$$\text{Newton's second law: } mg - T = ma_{cm}$$

$$T = mg - \frac{3mg}{4} = \frac{mg}{4}$$

15. (17) For vertical rod with axis at end P: $I_1 = \frac{ML^2}{3}$

For horizontal rod centered at distance L from P:

$$I_2 = \int_{-L/2}^{L/2} \frac{M}{L}(x^2 + L^2)dx = \frac{M}{L} \left[\frac{x^3}{3} + L^2x \right]_{-L/2}^{L/2}$$

$$= \frac{M}{L} \left[\frac{L^3}{12} + L^3 \right] = \frac{13ML^2}{12}$$

$$\text{Total: } I = \frac{ML^2}{3} + \frac{13ML^2}{12} = \frac{4ML^2 + 13ML^2}{12} = \frac{17ML^2}{12}$$

$$x = 17$$

16. (1) $\alpha = \frac{\tau}{I}$

$$I = \frac{1}{4}mR^2 + mR^2 + \frac{1}{4}mR^2 + m(2R)^2 + \frac{m(3R)^2}{12} + m\left(\frac{R}{2}\right)^2$$

$$= \left(\frac{3}{2} + 4 + 1\right)mR^2 = \frac{13}{2}mR^2 = \frac{13}{2} \times 600 \times 10^2 = 39 \times 10^4$$

$$\alpha = \frac{43 \times 10^5}{39 \times 10^4} \text{ rad/s}^2 = \frac{430}{39} \text{ rad/s}^2 \approx 11 \text{ rad/s}^2$$

17. (265) Using the parallel axis theorem for radius of gyration:

$k^2 = k_{cm}^2 + d^2$ where k_{cm} is the radius of gyration about the center of mass and d is the distance from the center.

For a solid sphere:

$$I_{center} = \frac{2}{5}MR^2, \text{ so } k_{cm}^2 = \frac{2}{5}R^2$$

With $R = 10 \text{ cm}$ and $d = 15 \text{ cm}$:

$$k^2 = \frac{2}{5}(10)^2 + (15)^2 = 40 + 225 = 265$$

Since $k = \sqrt{n}$, we have $n = 265$.

18. (2) From kinematics with $s = 0.81 \text{ m}$ and $t = 9 \text{ s}$: $a = 2s/t^2 = 0.02 \text{ m/s}^2$.

For the pulley system, applying Newton's second law to both masses and torque equation:

$$(m_1 - m_2)g - (m_1 + m_2)a = Ia/R^2.$$

Substituting values: $0.05 \times 9.8 - 0.75 \times 0.02 = I \times 50$ gives $0.49 - 0.015 = 50I$.

Therefore $I = 9.5 \times 10^{-3} \text{ kg}\cdot\text{m}^2$