CHAPTER

04 Viscosity

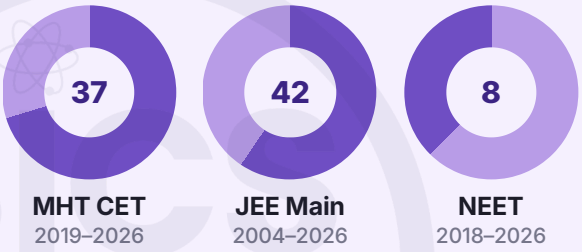
MHT CET · JEE · NEET Physics

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★	**Exam-Day Card & Formula Sheet**	10

EXAM WEIGHTAGE



	CET	JEE	NEET
Terminal Velocity	26 (70%)	25 (60%)	3 (38%)
Viscosity & Stokes' Law	11 (30%)	17 (40%)	5 (62%)

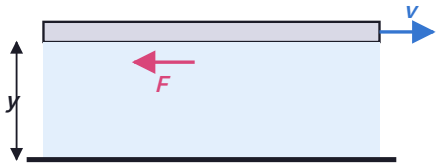
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01 CONCEPT Viscosity & Stokes' Law

IN ONE LINE

Viscosity is internal friction between layers of a fluid. On a slow sphere it gives a force **F = 6πηrv**.

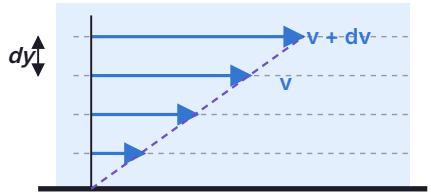
4.1.1 What is viscosity?



A layer of liquid drags on the next layer

- The property of a fluid that opposes relative motion between its layers.
- The viscous force is **tangential** to the layers.
- Layer in contact with a fixed surface is at rest; speed grows with height.
- Unlike solid friction, it depends on area and on the velocity gradient, not on normal reaction.

4.1.2 Newton's law of viscous flow



Velocity grows from the bottom layer upward

$$F = -\eta A \frac{dv}{dy}$$

- $\frac{dv}{dy}$ is the velocity gradient, A the area of the layer.
- Linear profile: gradient = $\frac{v}{d}$, so v ∝ height.

$$\text{Shear stress} = \eta \frac{dv}{dy}$$

4.1.3 Coefficient of viscosity

$$\eta = \frac{\text{Shear stress}}{\text{Velocity gradient}}$$

System	Unit
SI	N s m^{-2} = Pa s = decapoise
CGS	poise = dyne s cm^{-2}

1 Pa s = 10 poise

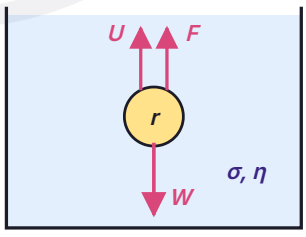
- Dimensions: [ML^{-1}T^{-1}].
- η depends on the nature of the fluid and its temperature.

4.1.4 Effect of temperature

Fluid	Heated	Why
liquid	η falls	cohesion weakens
gas	η rises	more molecular collisions

- Hot water flows faster than cold water.
- For a gas, η ∝ √T.
- Gases have far smaller viscosity than liquids.
- Ideal fluid: η = 0.

4.1.5 Stokes' law



Forces on a sphere falling in a fluid

F = 6πηrv

- Viscous force on a small sphere of radius r moving at speed v.
- F ∝ r and F ∝ v. It always opposes the motion.
- At constant velocity the sphere has no net force.

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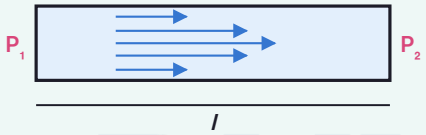
4.1.6 Viscous force at terminal velocity

$$F = W - U = mg\left(1 - \frac{\sigma}{\rho}\right)$$

- Ball rising steadily in a denser liquid: $F = U - W$.
- Liquid n times as dense as the ball: $F = (n - 1)W$.
- Heat produced per second = $F\,v \propto r^5$.

JEE · NEET Corner

Poiseuille's formula



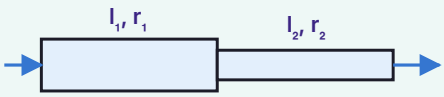
Flow is fastest along the axis

$$V = \frac{\pi P r^4}{8\eta l}$$

- V: volume of liquid flowing per second.
- Valid for steady flow in a narrow horizontal tube.

Liquid resistance

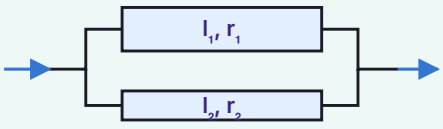
$$R = \frac{8\eta l}{\pi r^4} \Rightarrow V = \frac{P}{R}$$



Same Q

Series: same flow

$$P = P_1 + P_2 \cdot R = R_1 + R_2$$



Same P

Parallel: same pressure

$$V = V_1 + V_2 \cdot \frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$$

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Solved Examples 01 Viscosity & Stokes' Law

SOLVED 1 MHT CET 2024 · 15 May · Shift 2

The viscous force between two liquid layers is

(a) radial
(b) normal to the liquid surface
(c) tangential to the liquid surface
(d) neither purely tangential nor purely normal

STEP 1 Layers slide over one another
STEP 2 The force opposes this sliding
STEP 3 It is **tangential to the liquid surface**

Answer: **(c)**

SOLVED 2 NEET 2023

Which of the following statements is not true?

(a) Coefficient of viscosity is a scalar quantity
(b) Surface tension is a scalar quantity
(c) Pressure is a vector quantity
(d) Relative density is a scalar quantity

STEP 1 Pressure at a point has no definite direction
STEP 2 So pressure is a scalar
STEP 3 Not true: **(c)**

Answer: **(c)**

SOLVED 3 JEE Main 2024 · 27 Jan · Shift 1

Statement I: Viscosity of gases is greater than that of liquids. Statement II: Surface tension of a liquid decreases due to the presence of insoluble impurities.

(a) I is correct but II is incorrect
(b) I is incorrect but II is correct
(c) Both are incorrect
(d) Both are correct

STEP 1 Gases have much smaller viscosity: I is incorrect
STEP 2 Insoluble impurities lower T: II is correct
STEP 3 **I is incorrect, II is correct**

Answer: **(b)**

SOLVED 4 MHT CET 2025 · 19 Apr · Shift 2

Water flows steadily in a river. A and B are two layers of water at heights 40 cm and 90 cm from the bottom. The velocity of layer A is 12 cm/s. The velocity of layer B is

(a) 15 cm/s (b) 21 cm/s
(c) 27 cm/s (d) 36 cm/s

STEP 1 Bottom layer is at rest; $v \propto$ height
STEP 2 $v_B = 12 \times \frac{90}{40}$
STEP 3 v_B = **27 cm/s**

Answer: **(c)**

SOLVED 5 JEE Main 2014 · 19 Apr · Shift 1

The velocity of water in a river is 18 km/h near the surface. If the river is 5 m deep, the shearing stress between horizontal layers of water is ($\eta = 10^{-2}$ poise)

(a) 10^{-1} N m^{-2} (b) 10^{-2} N m^{-2}
(c) 10^{-3} N m^{-2} (d) 10^{-4} N m^{-2}

STEP 1 Gradient = $\frac{5\text{ m/s}}{5\text{ m}} = 1\text{ s}^{-1}$
STEP 2 $\eta = 10^{-2}$ poise = 10^{-3} Pa s
STEP 3 Stress = $\eta \times$ gradient = **10^{-3} N m^{-2}**

Answer: **(c)**

SOLVED 6 NEET 2023

The viscous drag on a metal sphere of diameter 1 mm, falling through a fluid of viscosity 0.8 Pa s with velocity 2 m/s, is

(a) 15×10^{-3} N (b) 30×10^{-3} N
(c) 1.5×10^{-3} N (d) 20×10^{-3} N

STEP 1 $F = 6\pi\eta r v$ with r = 0.5 mm
STEP 2 $= 6\pi \times 0.8 \times 0.5 \times 10^{-3} \times 2$
STEP 3 $\approx$ **15×10^{-3} N**

Answer: **(a)**

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Solved Examples 01 Viscosity & Stokes' Law (contd.)

SOLVED 7 NEET 2022 · Phase 2

The terminal velocity of a copper ball of radius 5 mm falling through oil is 10 cm/s. If the viscosity of the oil is 0.9 kg m^{-1} s^{-1}, the viscous drag force is

(a) 4.23×10^{-6} N (b) 8.48×10^{-3} N
(c) 8.48×10^{-5} N (d) 4.23×10^{-3} N

STEP 1 $F = 6\pi\eta rv$
STEP 2 $= 6\pi \times 0.9 \times 5 \times 10^{-3} \times 0.1$
STEP 3 $= \mathbf{8.48 \times 10^{-3}\ N}$

Answer: **(b)**

SOLVED 8 AIEEE 2004

Spherical balls of radius R fall in a viscous fluid of viscosity η with velocity v. The retarding viscous force on a ball is

(a) inversely proportional to both R and v
(b) directly proportional to both R and v
(c) directly proportional to R but inversely proportional to v
(d) inversely proportional to R, but directly proportional to v

STEP 1 Stokes' law: $F = 6\pi\eta Rv$
STEP 2 $F \propto R$ and $F \propto v$
STEP 3 **Directly proportional to both**

Answer: **(b)**

SOLVED 9 MHT CET 2026 · 15 May · Shift 2

The velocity of a small ball of mass M and density d, dropped in a container of glycerine, becomes constant after some time. If the density of glycerine is $\frac{d}{2}$, the viscous force on the ball is

(a) Mg (b) $\frac{3Mg}{2}$
(c) 2Mg (d) $\frac{Mg}{2}$

STEP 1 At constant velocity: F + U = W
STEP 2 $U = \frac{Mg}{2}$, since the liquid is half as dense
STEP 3 $F = \mathbf{\frac{Mg}{2}}$

Answer: **(d)**

SOLVED 10 MHT CET 2021 · 22 Sep · Shift 2

A ball rises to the surface of a liquid with constant velocity. The density of the liquid is four times that of the ball. The viscous force on the rising ball is greater than the weight of the ball by a factor of

(a) 4 (b) 3
(c) 2 (d) 5

STEP 1 Rising steadily: U = W + F
STEP 2 U = 4W
STEP 3 F = 3W: factor **3**

Answer: **(b)**

SOLVED 11 MHT CET 2026 · 11 Apr · Shift 1

A ball of radius 1 mm and density 10.5 g cm^{-3} is dropped in glycerine of viscosity 9.8 poise and density 1.5 g cm^{-3}. The viscous force at constant velocity is 3696×10^{-x} N. The value of x is (g = 9.8 m/s^2, $\pi = \frac{22}{7}$)

(a) 5 (b) 6
(c) 7 (d) 8

STEP 1 $F = \frac{4}{3}\pi r^3(\rho - \sigma)g$
STEP 2 $= \frac{4}{3} \times \frac{22}{7} \times 10^{-9} \times 9000 \times 9.8$
STEP 3 $= 3696 \times 10^{-7}\ \text{N} \Rightarrow x = \mathbf{7}$

Answer: **(c)**

SOLVED 12 NEET 2018

A small sphere of radius r falls from rest in a viscous liquid. Heat is produced by the viscous force. The rate of production of heat at terminal velocity is proportional to

(a) r^3 (b) r^2
(c) r^5 (d) r^4

STEP 1 Power = F v = $6\pi\eta r\, v^2$
STEP 2 $v \propto r^2$, so $v^2 \propto r^4$
STEP 3 Power $\propto \mathbf{r^5}$

Answer: **(c)**

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02 CONCEPT Terminal Velocity

IN ONE LINE

A falling sphere speeds up until weight balances upthrust and viscous force. Then it moves at a steady **terminal velocity**.

4.2.1 Forces on the sphere

- Weight $W = \frac{4}{3}\pi r^3 \rho g$, down.
- Upthrust $U = \frac{4}{3}\pi r^3 \sigma g$, up.
- Viscous force $F = 6\pi\eta r v$, up. It grows with v.

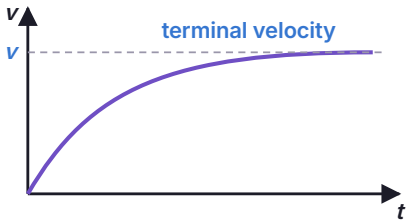
4.2.2 Terminal velocity

$$6\pi\eta r v + \frac{4}{3}\pi r^3 \sigma g = \frac{4}{3}\pi r^3 \rho g$$

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

- ρ: density of the sphere. σ: density of the fluid.
- $v \propto r^2$, $v \propto (\rho - \sigma)$, $v \propto g$, $v \propto \frac{1}{\eta}$.
- $\rho > \sigma$: falls. $\rho < \sigma$: rises (air bubble, v is upward).

4.2.3 Velocity against time



Rises from zero and levels off

- Velocity starts at zero and approaches v asymptotically.
- Acceleration falls from g′ to zero.
- A steady pull twice the effective weight gives the same speed upward.

4.2.4 Quick ratios

Change	Result
same liquid, same material	$v_1 : v_2 = r_1^2 : r_2^2$
same size, same liquid	$v_1 : v_2 = (\rho_1 - \sigma) : (\rho_2 - \sigma)$
same speed	$r^2(\rho - \sigma)$ is the same
mass m to 8m	r doubles, v is 4 times

- Rain drops: $v \propto r^2$ and surface area $\propto r^2$, so areas go as speeds.
- Volumes go as $v^{3/2}$.

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VISCOSITY

NEWTON'S LAW · STOKES · TERMINAL VELOCITY

LEVEL 1 · EASY

Topic-wise Previous Year Questions

MHT CET · NEET · JEE Main

26	5	2
questions	concepts	topics

CONTENTS

01	Viscosity & Stokes' Law	Q 1–8	8 Qs
02	Terminal Velocity	Q 9–26	18 Qs
	Answer key		

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TOPIC 01

Viscosity & Stokes' Law

8 PYQs · Easy 8 · Medium 0 · Difficult 0 | MHT CET 1 · NEET 2 · JEE 5

Concepts covered: Newton's law & coefficient of viscosity (5) · Viscous force on a moving sphere (3)

LEVEL 1 · EASY 8 questions

◆ Newton's law & coefficient of viscosity 5 Qs

1. The viscous force between two liquid layers is

MHT CET 2024 · 15 MAY · SHIFT 2

(a) radial.
(b) normal to the liquid surface.
(c) tangential to the liquid surface.
(d) neither purely tangential nor purely normal.

2. Which of the following statements is not true?

NEET 2023

(a) Coefficient of viscosity is a scalar quantity
(b) Surface tension is a scalar quantity
(c) Pressure is a vector quantity
(d) Relative density is a scalar quantity

3. Given below are two statements:

Statement I: The hot water flows faster than cold water

Statement II: Soap water has higher surface tension as compared to fresh water. In the light above statements, choose the correct answer from the options given below

JEE MAIN 2025 · 23 JAN · SHIFT 1

(a) Both Statement I and Statement II are false
(b) Both Statement I and Statement II are true
(c) Statement I is false but Statement II is true
(d) Statement I is true but Statement II is false

4. Given below are two statements:

Statement (I) :Viscosity of gases is greater than that of liquids.

Statement (II): Surface tension of a liquid decreases due to the presence of insoluble impurities. In the light of the above statements, choose the most appropriate answer from the options given below:

JEE MAIN 2024 · 27 JAN · SHIFT 1

(a) Statement I is correct but statement II is incorrect
(b) Statement I is incorrect but Statement II is correct
(c) Both Statement I and Statement II are incorrect
(d) Both Statement I and Statement II are correct

5. Given below are two statements: One is labelled as Assertion A and the other is labelled as Reason R.

Assertion A: Product of Pressure (P) and time (t) has the same dimension as that of coefficient of viscosity.

Reason R: Coefficient of viscosity = $\frac{Force}{Velocity\ gradient}$

Choose the correct answer from the options given below:

JEE MAIN 2022 · 28 JUN · SHIFT 1

(a) Both A and R are true, and R is the correct explanation of A.
(b) Both A and R are true but R is NOT the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

◆ Viscous force on a moving sphere 3 Qs

6. The viscous drag acting on a metal sphere of diameter $1\,\text{mm}$, falling through a fluid of viscosity $0.8\,\text{Pa s}$ with a velocity of $2\,\text{m s}^{-1}$ is equal to:

NEET 2023

(a) $15 \times 10^{-3}\,\text{N}$ (b) $30 \times 10^{-3}\,\text{N}$
(c) $1.5 \times 10^{-3}\,\text{N}$ (d) $20 \times 10^{-3}\,\text{N}$

7. A small rigid spherical ball of mass M is dropped in a long vertical tube containing glycerine. The velocity of the ball becomes constant after some time. If the density of glycerine is half of the density of the ball, then the viscous force acting on the ball will be (consider g as acceleration due to gravity)

JEE MAIN 2025 · 22 JAN · SHIFT 2

(a) 2 Mg (b) $\frac{3}{2}$Mg (c) $\frac{\text{Mg}}{2}$ (d) Mg

8. Spherical balls of radius R are falling in a viscous fluid of viscosity η with a velocity v. The retarding viscous force acting on the spherical ball is

AIEEE 2004

(a) inversely proportional to both radius R and velocity v
(b) directly proportional to both radius R and velocity v
(c) directly proportional to R but inversely proportional to v
(d) inversely proportional to R, but directly proportional to velocity v

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TOPIC 02

Terminal Velocity

18 PYQs · Easy 18 · Medium 0 · Difficult 0 | MHT CET 10 · NEET 1 · JEE 7

Concepts covered: Terminal velocity: radius & density (7) · Terminal velocity of merged drops (6) · Velocity-time graph & experiment (5)

LEVEL 1 · EASY 18 questions

◆ Terminal velocity: radius & density 7 Qs

9. A spherical object is falling under gravity through a viscous fluid. The sphere attains the terminal velocity when

MHT CET 2026 · 18 APR · SHIFT 1

(a) viscous force is zero.
(b) buoyant force is equal to force due to gravity
(c) viscous force plus force of gravity becomes equal to buoyant force.
(d) buoyant force plus viscous force becomes equal to force due to gravity.

10. Two identical drops of water are falling through air with steady velocity ' V '. If the two drops come together to form a single drop. The new velocity of the single drop is

MHT CET 2024 · 9 MAY · SHIFT 2

(a) $(2)^{1/3}$ V (b) $(2)^{3/2}$ V
(c) $(2)^{2/3}$ V (d) $(2)^{1/4}$ V

11. A steel ball of radius 6 mm has a terminal speed of 12cms^{-1} in a viscous liquid. What will be the terminal speed of a steel ball of radius 3 mm in the same liquid?

MHT CET 2024 · 3 MAY · SHIFT 2

(a) 12 cms^{-1} (b) 9 cms^{-1}
(c) 6 cms^{-1} (d) 3 cms^{-1}

12. A spherical metal ball of radius 'r' falls through viscous liquid with velocity 'V'. Another metal ball of same material but of radius $\left(\frac{r}{3}\right)$ falls through same liquid, then its terminal velocity will be

MHT CET 2023 · 12 MAY · SHIFT 2

(a) $\frac{V}{3}$ (b) $\frac{V}{4}$ (c) $\frac{V}{6}$ (d) $\frac{V}{9}$

13. The speed of a ball of radius 2 cm in a viscous liquid is 20 cm/s. What will be the speed of a ball of radius 1 cm in same liquid?

MHT CET 2021 · 23 SEP · SHIFT 1

(a) 10 cm/s (b) 4 cm/s (c) 5 cm/s (d) 8 cm/s

14. The terminal velocity (vt) of the spherical rain drop depends on the radius (r) of the spherical rain drop as:

JEE MAIN 2022 · 25 JUN · SHIFT 1

(a) r1/2 (b) r (c) r2 (d) r3

15. The terminal velocity of a metallic ball of radius 6 mm in a viscous fluid is 20 cm/s. The terminal velocity of another ball of same material and having radius 3 mm in the same fluid will be ____ cm/s.

JEE MAIN 2026 · 21 JAN · SHIFT 2 *(Numerical)*

◆ Terminal velocity of merged drops 6 Qs

16. 'n' small drops of water having same size fall through air with constant velocity 4 cm/s. They coalesce to form a big drop. The terminal velocity of the big drop is

MHT CET 2026 · 12 MAY · SHIFT 2

(a) $2n^{2/3}\,cm/s$ (b) $12n^{2/3}\,cm/s$
(c) $4n^{2/3}\,cm/s$ (d) $8n^{2/3}\,cm/s$

17. 125 small water drops of same size fall through air with constant velocity 4 cm/s. They coalesce to form a big drop. The terminal velocity of the big drop is

MHT CET 2025 · 26 APR · SHIFT 1

(a) 0.5 m/s (b) 1 m/s (c) 1.5 m/s (d) 2.5 m/s

18. Two rain drops of same radius are falling through air each with a steady speed of 5 cm/s. If the drops coalesce, the new steady velocity of big drop will be

MHT CET 2024 · 11 MAY · SHIFT 2

(a) 5 cm/s (b) $5\sqrt{2}$ cm/s
(c) $5 \times 2^{1/3}$ cm/s (d) $5 \times (4)^{1/3}$ cm/s

19. Eight identical drops of water falling through air with uniform velocity of 10 cm/s combine to form a single drop of big size, then terminal velocity of the big drop will be

MHT CET 2019 · 3 MAY · SHIFT 1

(a) 80 cm/s (b) 10 cm/s (c) 30 cm/s (d) 40 cm/s

20. Eight equal drops of water are falling through air with a steady speed of 10 cm/s. If the drops coalesce, the new velocity is:-

JEE MAIN 2023 · 11 APR · SHIFT 2

(a) 40 cm/s (b) 16 cm/s (c) 10 cm/s (d) 5 cm/s

21. Sixty four rain drops of radius 1 mm each falling down with a terminal velocity of 10 cm/s coalesce to form a bigger drop. The terminal velocity of bigger drop is ____ cm/s.

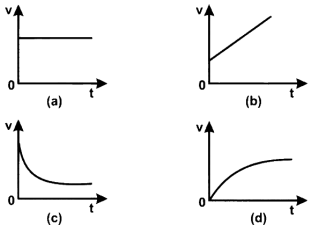
JEE MAIN 2026 · 24 JAN · SHIFT 1 *(Numerical)*

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◆ Velocity-time graph & experiment 5 Qs

22. A small metal sphere is falling through a viscous liquid. The variation of velocity (V) with time (t) is shown correctly in graph

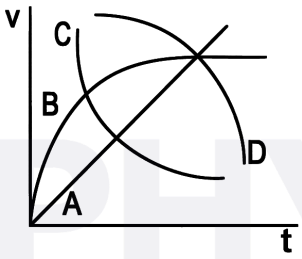
MHT CET 2026 · 20 APR · SHIFT 2



(a) b (b) a (c) d (d) c

23. A spherical ball is dropped in a long column of a highly viscous liquid. The curve in the graph shown, which represents the speed of the ball (v) as a function of time (t) is

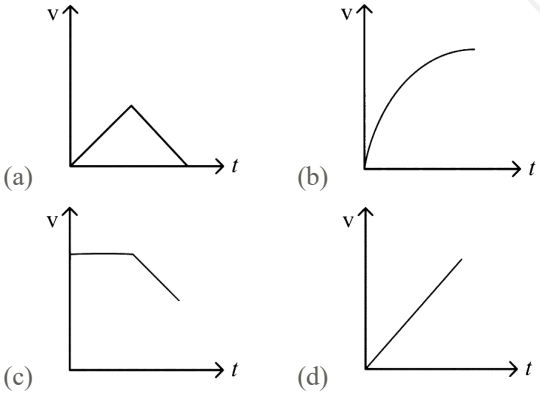
NEET 2022 · PHASE 1



(a) A (b) B (c) C (d) D

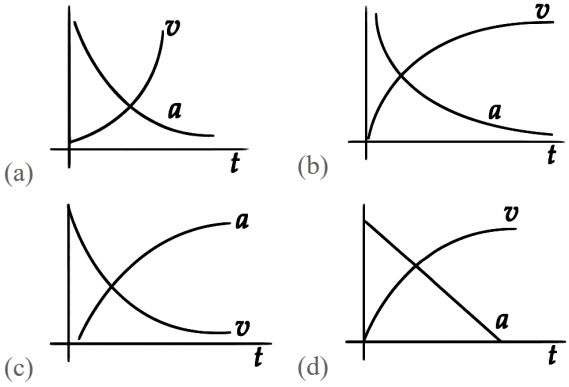
24. A small steel ball is dropped into a long cylinder containing glycerine. Which one of the following is the correct representation of the velocity time graph for the transit of the ball?

JEE MAIN 2024 · 31 JAN · SHIFT 1



25. Which of the following option correctly describes the variation of the speed v and acceleration 'a' of a point mass falling vertically in a viscous medium that applies a force F = − kv, where 'k' is a constant, on the body? (Graphs are schematic and not drawn to scale)

JEE MAIN 2016 · 9 APR · SHIFT 1



26. In an experiment, a small steel ball falls through a liquid at a constant speed of 10 cm/s. If the steel ball is pulled upward with a force equal to twice its effective weight, how fast will it move upward?

JEE MAIN 2013 · 25 APR · SHIFT 1

(a) 5 cm/s (b) Zero (c) 10 cm/s (d) 20 cm/s

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ANSWER KEY

Shaded by level: **Easy**

01 Viscosity & Stokes' Law

1. (c)	2. (c)	3. (d)	4. (b)	5. (c)	6. (a)	7. (c)	8. (b)		

02 Terminal Velocity

9. (d)	10. (c)	11. (d)	12. (d)	13. (c)	14. (c)	15. 5	16. (c)	17. (b)	18. (d)
19. (d)	20. (a)	21. 160	22. (c)	23. (b)	24. (b)	25. (b)	26. (c)		

Note: *"Bonus" = no option is correct as the question is printed (dropped in the official key). Numerical questions show the numerical answer.*

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