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1. Physicists are finding new ways to make electrons act strangely.

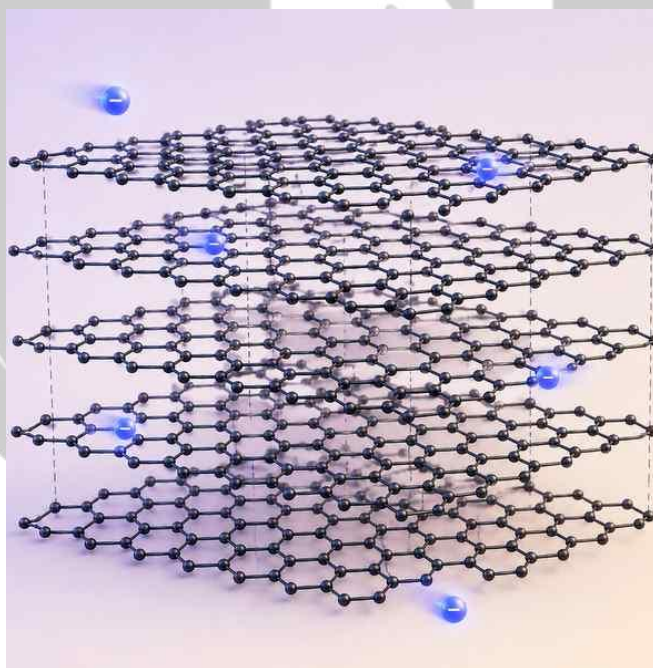
Why in the News?

Physicists have achieved a breakthrough by creating the Fractional Quantum Hall Effect (FQHE) without using an extremely strong magnetic field, a condition long believed to be indispensable. In 2024, a team at MIT successfully detected this "anomalous" version (FQAHE) in a specially engineered material called pentalayer graphene. This opens new doors for studying exotic particles that could revolutionise future quantum computers.

Background

The story begins with the Hall Effect (1879), where a magnetic field pushes moving electrons sideways, creating a voltage. Quantum mechanics later revealed that under intense magnetic fields and near absolute zero, this sideways resistance doesn't change smoothly but in discrete, whole-number steps-the Integer Quantum Hall Effect. This happens because electrons are forced into specific energy levels.

The truly strange discovery came in 1982: the Fractional Quantum Hall Effect (FQHE), where the resistance changes in fractions (like $1/3$, $2/5$). This is baffling because electrons are indivisible. The explanation is that under extreme conditions, many electrons interact strongly to form a collective quantum state-a "liquid"-where excitations behave like quasiparticles that carry only a fraction of an electron's charge. These quasiparticles, called anyons, are incredibly robust and hold promise for storing information in quantum computers.



Feature: The Breakthrough with Pentalayer Graphene

- **The Key Material:** Pentalayer graphene is a stack of five layers of atom-thin carbon, each twisted by a small angle relative to the one below. This arrangement forms a "moiré superlattice."
- **The Mechanism:** This structure dramatically slows the electrons down. Usually, electrons zip past each other too fast to interact strongly. In this configuration, their kinetic energy drops

so low that their mutual repulsion becomes the dominant force. Instead of flying apart, the confined electrons organise themselves into the desired collective quantum state.

- **The Result:** This effect, achieved without an external magnetic field, is the **Fractional Quantum Anomalous Hall Effect (FQAHE)**.

Challenge

- **Extreme Conditions Persist:** The material must still be extremely pure and cooled to very low temperatures.
- **Precision Engineering:** The angles at which the graphene layers are twisted must be incredibly precise. A tiny deviation ruins the necessary moiré superlattice properties.
- **Fine-Tuned Control:** The FQAHE state only appears when the material has the exact right number of electrons, controlled by applying a specific voltage.

Way Forward

The path forward involves continuous refinement. Physicists are already fine-tuning these controls (purity, twist angle, temperature, voltage) to create more robust and stable FQAHE states. The main driving force is the immense value of anyonic quasiparticles for advanced quantum computing, where they could protect sensitive information from noise, one of the field's hardest unsolved problems. This work also unlocks a "whole world of physics" previously trapped behind powerful and expensive magnets.

Conclusion

The discovery of FQAHE in pentalayer graphene is a landmark achievement in the field of quantum materials. Science progresses by recreating nature's phenomena in new, more accessible ways—just as understanding aerodynamics led to air travel. By figuring out how to "fake" a powerful magnetic field within the structure of a material itself, researchers have made a strange and potentially transformative quantum effect far more accessible, paving the way for discoveries that could one day reshape computing and our understanding of matter.

2. Finance Commission transfers and equity issue

Why in the News?

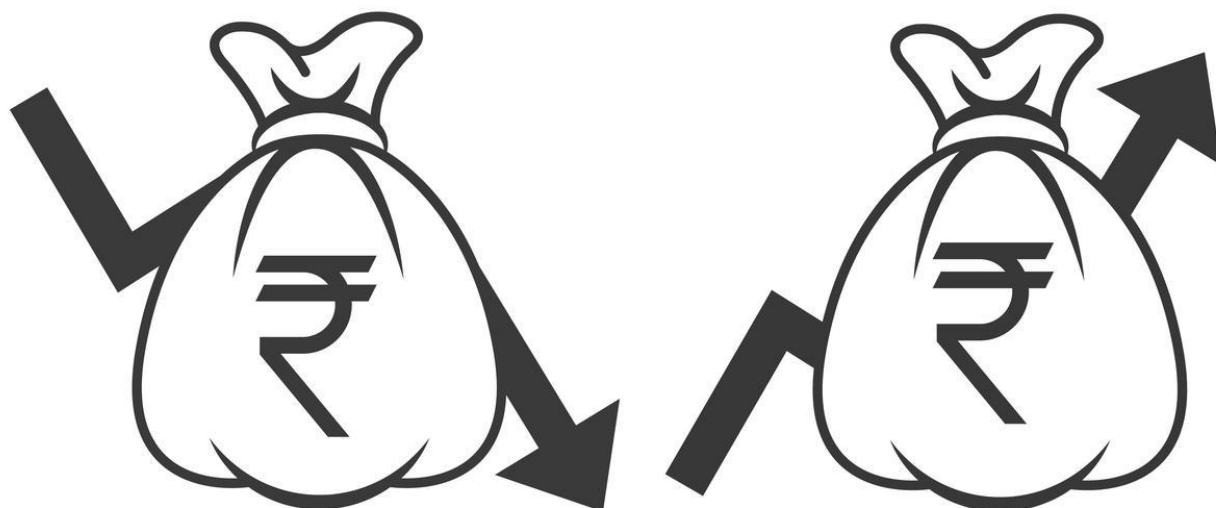
The recommendations of the 16th Finance Commission have generated debate over fiscal devolution and equity among Indian States. Southern and economically stronger States have expressed concerns regarding declining shares in tax devolution despite their higher contribution to the national economy and better fiscal performance.

Background

The Finance Commission is a constitutional body established under Article 280 of the Indian Constitution. It recommends the distribution of tax revenues between the Centre and the States (vertical devolution) and among the States themselves (horizontal devolution). The **16th Finance Commission retained the States' share at 41% of divisible central taxes** and continued to emphasise equity as the guiding principle in horizontal transfers. Over time, fiscally weaker States such as **Bihar, Uttar Pradesh, Madhya Pradesh, and West Bengal have received larger shares due to the income-distance criterion**, while the combined share of southern States like **Tamil Nadu, Karnataka, Kerala, and Andhra Pradesh has declined**. States have also raised concerns over the growing use of cesses and surcharges, which are excluded from the divisible pool, thereby reducing the effective share of States in Union revenues.

Features

The 16th Finance Commission retained the **41% vertical devolution** share for States. For horizontal distribution among States, the Commission assigned the highest **weight to income distance (42.5%)**, followed by population, area, forest cover, demographic performance, and contribution to national GDP. The Commission replaced the “**tax effort**” criterion with “**States’ contribution to national GDP.**” However, instead of using actual GSDP shares, it applied a square-root transformation, reducing the relative advantage of economically stronger States. The Commission also abolished revenue-deficit grants and sector-specific grants and recommended stricter fiscal discipline by discouraging off-budget borrowings and limiting fiscal deficits to below 3%. There was only a marginal shift toward efficiency-based criteria, with efficiency-related weight increasing from **25% under the 15th Finance Commission to 30% under the 16th Finance Commission.**



Challenges

A major challenge is the declining share of economically stronger and better-performing States despite their **larger contribution to GDP and tax revenues**. Southern States argue that they are being penalised for better governance, lower population growth, and stronger fiscal discipline. The heavy reliance on the **income-distance criterion disproportionately favours poorer States and may weaken incentives for fiscal discipline** and revenue mobilisation. Another issue is the increasing use of cesses and surcharges by the Union government. Since these are excluded from the divisible pool, States receive a smaller effective share of total revenues. States also face reduced fiscal autonomy because of the growing dominance of Centrally Sponsored Schemes (CSS), where States often bear a significant share of programme costs.

Despite large fiscal transfers, regional disparities in public expenditure on health and education continue to persist, showing that transfers alone have not ensured convergence in development outcomes. There are also concerns that future delimitation may strengthen the political influence of populous States, potentially affecting the fairness of fiscal transfers.

Way Forward

Future Finance Commissions should strike a better balance between equity and efficiency by rewarding **fiscal discipline, governance quality, tax effort, and economic contribution alongside support for poorer States**. The Centre should rationalise cesses and surcharges by either including more of them in the divisible pool or imposing a cap on their use. A more data-driven and transparent approach should be adopted for assigning weights to devolution criteria. Indicators such as fiscal capacity, human development outcomes, and governance performance can improve fairness and efficiency. Strengthening cooperative federalism through greater consultation with States and ensuring predictable fiscal transfers would enhance trust between the Centre and States. Finally, fiscal transfers should be linked with accountability and effective utilisation of funds to improve public service delivery and reduce regional disparities.

Conclusion

The recommendations of the **16th Finance Commission highlight the continuing tension between equity and efficiency in India's fiscal federal structure**. While supporting poorer States remains essential for balanced regional development, excessive reliance on redistribution may discourage fiscal discipline and economic performance. Therefore, future Finance Commissions must adopt a more balanced, transparent, and data-driven approach that rewards good **governance, tax effort, and developmental outcomes while ensuring adequate support to weaker States**. Strengthening cooperative federalism and ensuring fair fiscal devolution will be crucial for maintaining national unity and inclusive growth.

3. India and Australia – bridging the trade and trust barrier

Why in the News?

India and Australia are likely to conclude a Comprehensive Economic Cooperation Agreement (CECA) during the visit of Australian Foreign Minister Penny Wong to India for the Quad Foreign Ministers' meeting. The proposed agreement aims to expand the 2022 Economic Cooperation and Trade Agreement (ECTA), amid rising geopolitical uncertainties, tariff politics, and India's need to diversify trade and investment partnerships.

Background

- **Asymmetric ECTA:** The 2022 ECTA created an imbalance. Australian exports to India now make up nearly two-thirds of the \$24 billion bilateral merchandise trade.

Uneven Trade Structure:

- **Services:** Dominated by Australian higher education, which accounts for ~60% of the \$10 billion bilateral services trade.
- **Investment:** Flows the opposite way. Indian investment in Australia (~32billion) exceeds Australian FDI in India
- 32billion)farexceedsAustralianFDIinIndia(18 billion).

- **Australia's Core Demand:** Canberra is pushing hard for parity in market access, particularly in agriculture, which India has heavily protected in all its major trade deals.

Challenge

- **The Agriculture Impasse:** This is the central, most difficult problem.
- **A Clash of Systems:** Indian agriculture is a livelihood for over half the population with tiny, vulnerable farms (avg. 0.73 hectares). Australian agriculture is a large-scale export industry (avg. farm >1,400 hectares).
- **Political Necessity vs. Economic Logic:** For India, protecting its market from cheap imports like Australian wheat is not a bargaining chip but a political necessity for food security. For Australia, pushing for full market access is an economic imperative.
- **Uneven Gains:** Even with protections, Australian farm exports to India have risen by 90% under ECTA, while Indian farm exports to Australia grew only 35%. The concept of a "level playing field" is a misframing of two fundamentally different systems.

Way Forward

- **Shift Focus from Tariffs to Standards:** The future should depend less on tariff cuts and more on mutual recognition of biosecurity and phytosanitary standards (e.g., digital certification, quarantine protocols). This gives Indian farmers a fair shot in the Australian market without solely opening India's.
- **Import Australia's Agri-Tech Systems:** India needs Australian expertise in precision farming, cold-chain infrastructure, water management, and climate adaptation to combat its massive 15-35% post-harvest losses. This knowledge sharing must be paired with Australian investment in India's agricultural logistics and technology.
- **Investment for Market Access:** India should trade some market access for real Australian investment inside its agricultural sector, creating a deeper partnership through initiatives like the Smart Farm Network.

Conclusion

- **Complementarity over Parity:** The new FTA should not aim for absolute symmetry in market access alone. Instead, it must be built on complementarity across trade and investment.
- **A Holistic Bargain:** India's core question should be whether it can trade some agricultural market access for a more balanced overall relationship, leveraging Australia's demand to secure investments and technology that strengthen its own farm sector.

4. Water governance in peri-urban areas

Why in the News?

India's peri-urban water governance challenges have gained attention due to rapid urbanisation, increasing pressure on water resources, and the lack of institutional mechanisms in expanding Census towns. Concerns over groundwater contamination, sanitation failures, and unequal water distribution have highlighted the urgent need for sustainable peri-urban water management.



Background

- **Institutional Limbo:** Peri-urban areas suffer from a governance vacuum. They are neither governed by effective Panchayati Raj Institutions nor by fully functional urban local bodies, leaving residents with "urban prices without urban services."

Case Studies of Failure:

- **Rawta Village (Delhi edge):** Water is supplied on alternate days only for a few hours at night via a common collection point, forcing residents to sacrifice sleep.
- **Gurugram:** The abolition of rural governance and transfer to a struggling municipal corporation created administrative inefficiency.
- **Hyderabad:** Toxic leachate from urban waste dumps contaminates peri-urban groundwater.
- **Bisalpur Dam (Jaipur):** Water originally for irrigation is diverted to meet urban demand, sacrificing downstream farmers without accountable governance.
- **Sanitation Paradox:** Despite the success of the Swachh Bharat Mission in building toilets, ~40 million urban households use on-site systems like septic tanks. Irregular desludging and routine illegal dumping of septage into rivers and fields directly undo these gains.

Challenge

- **A Zone of Sacrifice:** The peri-urban becomes an extraction zone for cities, supplying water and absorbing waste (like septage and leachate) without receiving commensurate services or political attention.
- **Source Unsustainability:** The Jal Jeevan Mission's focus on tap connections has outpaced efforts to protect water sources from encroachment and pollution.
- **Market Failure and Exploitation:** Erratic public water supply creates a gap filled by exploitative private water vendors.
- **Sewage Treatment Gap:** Centralised sewage treatment plants are often too distant from sprawling peri-urban settlements to be viable.

Way Forward

- **Resolve Governance Vacuum:** Constitute Nagar Panchayats for all Census towns as per the 74th Constitutional Amendment. Build functional capacity using models like the multi-stakeholder platform in Sultanpur village to force institutional coordination.

- **Secure Drinking Water Sources:** Shift focus from just connections to source sustainability. This involves protecting catchments, preventing waste dumping, and adopting community-driven sanitary inspections, as trialled in Maharashtra.
- **Launch SBM 3.0 for Peri-Urban Sanitation:** A new mission under the Ministry of Jal Shakti must prioritise faecal sludge management by:
 - Building faecal sludge treatment plants (FSTPs) where sewage plants are too distant.
 - Deploying GPS-equipped desludging trucks to prevent illegal dumping.
 - Introducing mini-cesspool vehicles for narrow lanes (as in Berhampur, Odisha).
 - Making services affordable via a small sanitation levy on monthly water bills.
- **Scale Decentralised Wastewater Tech:** Move startups like Indra Water and Tigreen beyond incubation. These modular systems treat water on-site, recovering 95% with minimal land use. This requires policy signals, public procurement mandates, and a market for treated water.
- **Finance as Strategic Infrastructure:** Adopt innovative models like Uttarakhand's blended finance structure, which combines state risk-bearing with World Bank loans tied to performance indicators, and extend them to septage management.

Conclusion

Peri-urban India, with its demographic weight and economic dynamism, will determine the country's water future. The choice is to plan deliberately now or inherit a legacy of chronic problems. By acting on these five fronts, the neglected "missing middle" can be transformed into a dense, thriving, and water-secure core.

5. Why is the Indian rupee falling?

Why in the News?

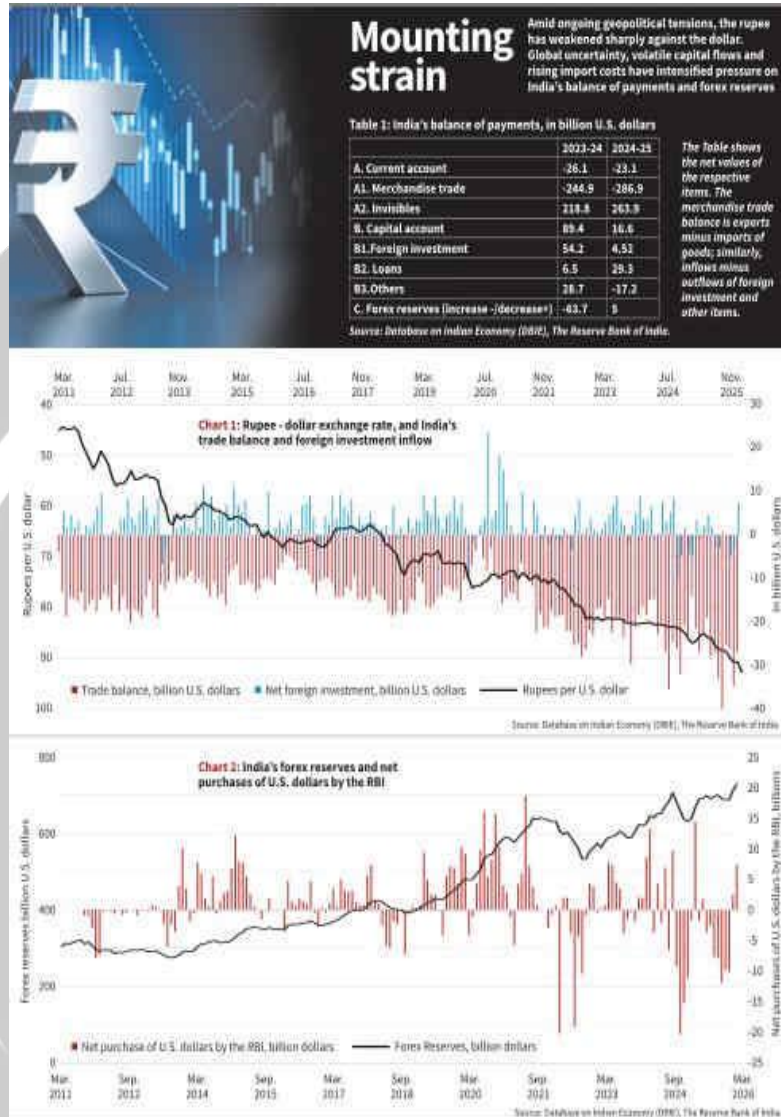
The Indian rupee has sharply depreciated against the U.S. dollar, with the rupee-dollar exchange rate crossing ₹96 per dollar in May 2026 compared to around ₹85 a year ago. The development has triggered concerns about inflation, rising import bills, trade deficits, and external sector stability in India.

- **Sharp Depreciation:** The Indian rupee has been on a sharp downward trajectory. The exchange rate crossed ₹96 per US dollar in May 2026, a significant fall from around ₹85 a year ago.
- **Geopolitical Context:** The recent decline is driven primarily by foreign investors withdrawing from India and retreating to the safety of their home bases amid growing geopolitical tensions and higher US interest rates.
- **Impending External Risks:** The situation is compounded by the ongoing threat of further oil price increases, posing a dual risk of India paying more dollars per barrel of oil and more rupees per dollar.

Background

- **Supply and Demand:** The exchange rate is the price of a currency determined by market demand and supply. Demand for the rupee rises with exports and foreign investment inflows, and falls with imports and capital outflows.
- **Balance of Payments Link:** The exchange rate is closely tied to the Balance of Payments. India consistently runs a merchandise trade deficit (imports, especially oil, exceed exports).

- This deficit is partially offset by a surplus in "invisibles" - primarily software service exports and remittances from migrant workers.
- The net result is a current account deficit (CAD), meaning India owes more foreign currency than it earns.
- **Capital Account Role:** This current account gap is bridged by inflows through the capital account (foreign investment and loans). A surplus here can offset the CAD and add to India's foreign exchange (forex) reserves.



Feature

- **FPI vs. FDI:** A key structural feature is the distinction between stable Foreign Direct Investment (FDI) and volatile Foreign Portfolio Investment (FPI). FPI, involving stocks and bonds, is described as "highly volatile and driven by speculation."
- **Pattern of Destruction:** When FPI exits, investors sell rupee assets for dollar assets, directly crashing the demand for the rupee. Every historical period of rapid rupee depreciation (2013, 2018, 2020, 2022, 2024-25, and the current 2025-26 phase) has been characterised by FPI outflows, a worsening trade account, or both.

Challenge

- **Imported Inflation and Costs:** The depreciation imposes a high cost. A

- 100barrelofoilcosts₹9,600(at₹96/
- 100barrelofoilcosts₹9,600(at₹96/) compared to ₹8,500 (at ₹85/\$), directly fueling inflation and worsening the import bill.
- Limited Export Benefit: While a weaker rupee can theoretically boost exports by making them cheaper, the article argues this benefit is limited due to the range of supply and demand constraints weighing on Indian manufacturing.
- Speculative Vulnerability: The economy is highly vulnerable to the "trail of destruction" left by speculative FPI outflows, which can rapidly destabilise the currency.

Way Forward

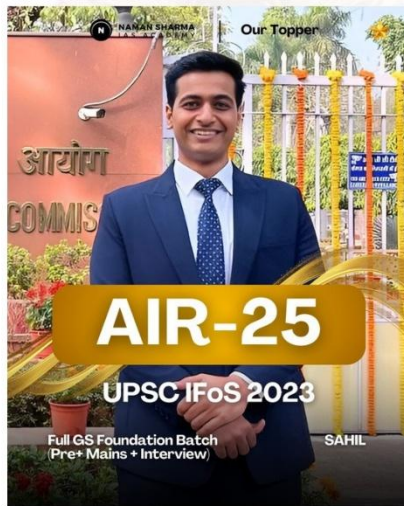
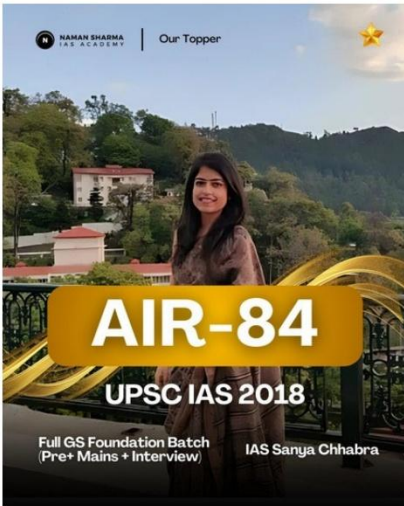
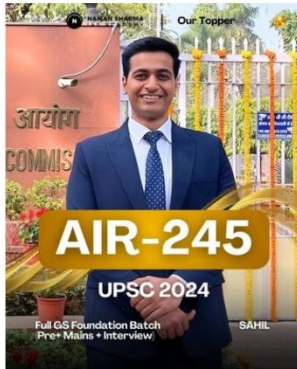
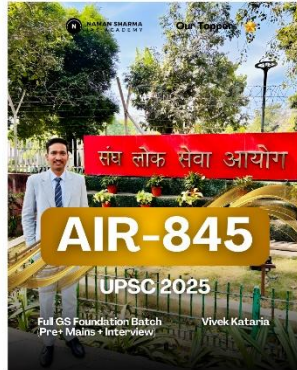
- Regulate Speculative Capital: India must take steps to regulate speculative capital outflows to reduce the extreme volatility caused by FPI movements.
- Reduce Import Dependence: The country must strategically reduce its critical dependence on oil imports, which is the structural cause of the persistent trade deficit and a major source of currency pressure.

Conclusion

The depreciation of the Indian rupee reflects structural challenges in India's external sector, including trade deficits, dependence on imported energy, and volatile global capital flows. While a weaker rupee may improve export competitiveness, excessive depreciation increases inflationary pressures and external vulnerabilities. A balanced approach involving export promotion, energy security, prudent capital flow management, and effective RBI intervention is essential for ensuring long-term economic resilience and currency stability.

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