Section 1: Short Answer Questions

Answer each question concisely (150-200 words).

1. **Compare and contrast LangChain and AutoGen frameworks.** Discuss their core functionalities, ideal use cases, and key limitations.

   What each framework is (core idea)

- **LangChain** — a general-purpose LLM application framework that makes it easy to build chains, retrievers/RAG, memory, tools, and single- or multi-step "agent" flows. It's an ecosystem: many connectors (vector DBs, APIs), helpers for prompt templates, and a large community.
- **AutoGen** — a framework focused on **multi-agent orchestration, structured agent dialogues, and long-running/complex workflows** where multiple LLM-based actors (and humans) interact in a managed protocol. It emphasizes role-based messaging, reproducible conversations, and orchestration patterns for collaborative problem solving.

Core functionalities (what each gives you out of the box)

LangChain

- Prompt templates, chain building, and composable primitives (map/reduce, sequential chains).
- Agents that can call tools (APIs, search, code execution) and decide next actions.
- Memory abstractions (short/long-term, conversational).
- Retriever + vector DB integrations for RAG.
- Many community-built connectors, examples, and templates for common app types (chatbots, assistants, RAG apps).
- Focus on single-agent pipelines and developer productivity.

AutoGen

- First-class multi-agent conversation primitives: roles (agents, humans, workers), message passing, turn management.
- Orchestration utilities for pipelines composed of interacting agents (including hierarchical/worker patterns).
- Support for long-running tasks, reproducible logs/transcripts, and programmatic replay/testing of interactions.
- Built-in patterns for role-playing, deliberation among multiple LLMs, and structured protocol design.

- More emphasis on controlling inter-agent protocols and message formats than on external connectors.

Ideal use cases

Pick LangChain when you want to:

- Build RAG-enabled assistants, chatbots, or single-agent apps quickly.
- Integrate vector stores, files, or third-party APIs with simple primitives.
- Prototype production-ready LLM apps with many off-the-shelf integrations.
- Use agent patterns where one LLM coordinates calling tools and simple subroutines.

Pick AutoGen when you want to:

- Model complex workflows that require multiple collaborating agents (e.g., "planner" + "executor" + "validator").
- Simulate or orchestrate human–AI or multi-AI conversations with reproducibility and structured roles.
- Run long-horizon tasks where interaction protocols, turn-taking, and reproducible transcripts are critical (e.g., simulations, complex decision pipelines, multi-step negotiation).
- Require fine-grained control over inter-agent messaging and testing of agent interplay.

Key limitations / trade-offs

LangChain limitations

- As complexity increases (many chains, complex agent logic) control and debugging can get harder — chains can become brittle.
- Large, evolving API surface and many community integrations can cause fragmentation; not every connector is maintained equally.
- Agents built directly on LLMs still suffer from hallucinations and may need careful guardrails and verification.
- For multi-agent orchestration and sophisticated role-play protocols, LangChain alone may be verbose or require custom engineering.

AutoGen limitations

- Smaller ecosystem of ready-made connectors (vector DBs, hosted services) compared with LangChain — more infra plumbing may be required.

- Steeper upfront design: you must design the agent roles, message protocol, and orchestration carefully.
- Less “out-of-the-box” for single-agent RAG pipelines and quick prototypes — not as focused on easy integration with many third-party tools.
- Community, docs, and examples may be less extensive depending on the project’s maturity.

2. **Explain how AI Agents are transforming supply chain management.** Provide specific examples of applications and their business impact.

How AI Agents Are Transforming Supply Chain Management

AI agents bring three core capabilities to supply chain operations:

1. **Autonomy** – they make decisions without waiting for human intervention.
2. **Adaptivity** – they replan when new data arrives (delays, shortages, demand shocks).
3. **Coordination** – they can collaborate with other agents (procurement agent, logistics agent, inventory agent).

These features allow supply chains to operate faster, smarter, and with fewer disruptions.

Demand Forecasting & Inventory Optimization

Application

AI forecasting agents continuously monitor:

- POS data
- Seasonal trends
- Promotions
- Market sentiment
- Weather
- Competitor pricing

They re-run models automatically when anomalies appear.

Example

A retail AI agent detects an unexpected rise in demand for umbrellas due to sudden weather changes. It:

- Updates the demand forecast
- Triggers auto-replenishment
- Notifies distribution centers

Business Impact

- **20–40% reduction in stockouts**
- **10–25% lower inventory carrying costs**
- Prevention of over-ordering and markdown losses

Dynamic Route Planning & Autonomous Logistics

Application

AI logistics agents continuously optimize transportation routes based on:

- Traffic conditions
- Port delays
- Fuel prices
- Carrier performance
- Delivery time windows

Example

A trucking company uses an AI routing agent that re-plans driver routes every 5 minutes to avoid congestion or weather disruptions.

Business Impact

- **10–15% lower fuel consumption**
- **25% faster delivery times**
- **Higher on-time delivery performance (OTD)**

Supplier Risk Monitoring & Procurement Automation

Application

Procurement agents automatically evaluate supplier risks by monitoring:

- Shipment delays
- Financial stability
- Political changes
- Quality metrics
- ESG compliance

Example

A procurement AI agent flags a supplier in Vietnam that is experiencing power outages and auto-recommends alternative vendors based on price, lead time, and past performance.

Business Impact

- **Reduced supplier disruptions**
- **Improved contract compliance**
- **Faster sourcing cycles (up to 50% reduction)**

Warehouse Automation & Real-Time Decision Support

Application

Warehouse agents coordinate:

- Robot pickers
- Sorting systems
- Slotting optimization
- Labor allocation

They also detect bottlenecks (e.g., congestion in aisles) and reassign workloads dynamically.

Example

An AI agent identifies order spikes at 3 PM daily and automatically reallocates robots and workers to high-demand zones.

Business Impact

- **30% higher picking efficiency**
- **Lower labor costs**
- Improved warehouse throughput

End-to-End Visibility and Exception Management

Application

AI agents act as “control tower” overseers:

- Detect disruptions (delayed containers, failed EDI transactions)
- Diagnose root causes
- Recommend or automatically execute fixes

Example

A shipment stuck at customs triggers an alert.
The AI agent:

- Contacts the freight forwarder

- Requests missing documents
- Rebooks the next carrier if needed

Business Impact

- **70–80% reduction in manual exception handling**
- Faster issue resolution
- Lower downstream impacts on production schedules

Autonomous Planning Across the Entire Supply Chain

Advanced enterprises use **multi-agent systems** where each agent specializes in a function (demand, supply, production, logistics) and negotiates with others.

Example

- A demand agent predicts a spike.
- The inventory agent checks safety stock.
- The production agent recalculates capacity.
- The procurement agent orders materials.

All autonomously and in seconds.

Business Impact

- **Shorter planning cycles (from weekly to real-time)**
- More resilient operations
- Improved service levels and customer satisfaction

3. **Describe the concept of "Human-Agent Symbiosis" and its significance** for the future of work. How does this differ from traditional automation?

Human–Agent Symbiosis: Concept, Significance, and How It Differs from Traditional Automation

What is Human–Agent Symbiosis?

Human–Agent Symbiosis refers to a collaborative relationship where **human workers and AI agents work together as partners**, each contributing complementary strengths.
Instead of replacing humans, AI agents act as **supportive co-workers** that adapt, reason, and interact dynamically with people.

Key characteristics

- **Shared decision-making** (AI proposes, human approves or corrects)

- **Continuous feedback loops** (AI learns from human actions)
- **Adaptive autonomy** (agent can operate alone but defers to humans when needed)
- **Complementary strengths**:
    - Humans → judgment, creativity, ethics
    - Agents → speed, pattern recognition, automation

It is inspired by *symbiotic computing*: a system where both human and machine improve because of their interaction.

Why It Matters: Significance for the Future of Work

1. Enhances Human Productivity, Not Just Efficiency

Agents help workers:

- Prioritize tasks
- Analyze data instantly
- Draft documents, reports, or recommendations
  This shifts workers from repetitive tasks to **higher-value, judgment-intensive roles**.

2. Reduces Cognitive Load

Agents act as "thinking assistants," handling:

- Information overload
- Routine checks
- Monitoring and alerts
  This allows humans to focus on strategic decisions.

3. Expands Human Capabilities

AI agents can give workers abilities they didn't previously have:

- Faster decision-making
- Real-time simulation and prediction
- Access to expert knowledge on demand

This leads to **augmented intelligence**, not replacement.

4. Safer and More Reliable Workflows

In high-stakes domains (healthcare, manufacturing, aviation):

- Agents detect anomalies
- Provide decision support
- Request human approval for risky actions

This combination reduces error rates and increases safety.

5. Enables New Work Models

Human–agent teams make possible:

- 24/7 hybrid operations
- Personalized AI "co-workers" for each employee
- Faster onboarding (agents act as tutors or guides)
- Specialized corporate knowledge agents

How Human–Agent Symbiosis Differs from Traditional Automation

Dimension	Traditional Automation	Human–Agent Symbiosis
Goal	Replace human labor	Collaborate with humans
Flexibility	Rigid, rule-based workflows	Adaptive, context-aware agents
Decision-making	Predefined logic	Shared intelligence (AI + human judgment)
Error handling	Stops or fails when unexpected input appears	Agent seeks human guidance and replans
Learning	None (static)	Continuous improvement via feedback
Human role	Monitor or execute exceptions	Actively collaborate, supervise, refine
Complexity of tasks	Simple, repetitive, predictable	Complex, ambiguous, dynamic

In essence:

- **Automation** = "Do exactly this."
- **Symbiosis** = "Let's solve this together, using our different strengths."

4. **Analyze the ethical implications of autonomous AI Agents in financial decision-making.** What safeguards should be implemented?

Ethical Implications of Autonomous AI Agents in Financial Decision-Making

Autonomous AI agents are increasingly used in **trading, lending, portfolio management, and fraud detection**. While they offer efficiency and predictive power, their use raises **significant ethical concerns**.

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1. Key Ethical Implications

a) Bias and Fairness

- AI agents trained on historical financial data may **reinforce existing biases** (e.g., against certain demographics in credit scoring).
- **Impact:** Certain groups may be unfairly denied loans or offered worse rates.

b) Transparency and Explainability

- Many AI agents (especially LLMs or deep learning models) are **black boxes**, making it hard to explain decisions to regulators or clients.
- **Impact:** Customers may be denied credit or investment opportunities without understanding why, undermining trust.

c) Accountability and Liability

- If an AI agent makes a poor financial decision (e.g., bad trade or misallocation of funds), it can cause **significant monetary loss**.
- **Ethical question:** Who is responsible—the AI developer, the financial institution, or the end-user?

d) Manipulation and Conflicts of Interest

- Autonomous agents could act in ways that **prioritize institutional profit over client interests**, e.g., maximizing trades for commission rather than client benefit.
- **Impact:** Potential for unethical financial practices or regulatory violations.

e) Security and Privacy

- Financial AI agents process sensitive customer data. Breaches or misuse can cause **financial and reputational harm**.

f) Over-Reliance on Automation

- Blind trust in autonomous agents can lead to **catastrophic market events**, as seen with flash crashes triggered by algorithmic trading.

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2. Safeguards and Best Practices

To ethically deploy autonomous AI in finance, institutions should implement multiple layers of safeguards:

a) Human-in-the-Loop (HITL)

- Require **human approval for high-risk or high-value decisions**.
- Example: Agents suggest trades, humans execute or veto them.

b) Explainability and Transparency

- Ensure agents can **provide understandable explanations** for decisions.
- Use explainable AI (XAI) techniques for audits and client communication.

c) Bias Mitigation

- Regularly audit models for **disparate impact** on different demographic groups.
- Use fairness-aware ML techniques (reweighting, adversarial debiasing).

d) Accountability Frameworks

- Clearly assign responsibility for decisions.
- Maintain **audit trails** to trace agent actions and decision rationale.

e) Risk Management and Limits

- Define **operational boundaries**: maximum trade size, exposure limits, or credit thresholds.
- Use simulation and stress-testing before deployment.

f) Privacy and Data Security

- Encrypt sensitive customer data and enforce strict access controls.
- Comply with financial regulations (e.g., GDPR, PCI DSS).

g) Continuous Monitoring and Feedback

- Monitor real-time behavior and detect anomalies or unexpected patterns.
- Implement **automatic rollback or alerts** for suspicious actions.

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3. Example Scenario

Autonomous Lending Agent

- Suggests loan approvals based on applicant data.
- Ethical risks:
  - May deny minority applicants due to biased historical data.
  - Could offer loans beyond a client's capacity, prioritizing institutional profit.
- Safeguards:
  - HITL approval for unusual applications.
  - Bias audits every quarter.
  - Transparent explanation sent to applicant.
  -

5. **Discuss the technical challenges of memory and state management in AI Agents.** Why is this critical for real-world applications?

Memory and State Management in AI Agents

AI agents are often **long-running, goal-driven systems** that interact with environments, users, or other agents over time. Effective **memory and state management** enables agents to retain relevant information, reason about the past, and plan for the future.

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1. What Memory and State Management Means

- **Memory:** Storage of relevant knowledge, observations, and past interactions.
  - Examples: conversation history, environmental observations, prior actions, learned patterns.
- **State:** The agent's current understanding of the environment and its own internal context.
  - Examples: current goals, pending tasks, ongoing workflows, partial computations.

Memory and state allow AI agents to:

- Maintain **continuity** across interactions
- **Plan** multi-step actions
- Make **context-aware decisions**

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2. Technical Challenges

a) Long-Term Memory Storage and Retrieval

- Challenge: Agents may need to recall relevant information from **large histories** or external knowledge sources.
- Technical issues:
  - Efficiently indexing and searching memory
  - Integrating structured (databases) and unstructured (text embeddings) data
  - Avoiding memory bloat over time
- Example: A customer support agent must remember prior complaints across months without slowing down.

b) Contextual Relevance

- Not all memory is equally important; the agent must **prioritize relevant information**.
- Challenge: Designing algorithms to filter and summarize past interactions without losing essential context.
- Example: Forgetting irrelevant past promotions but retaining information about customer preferences.

c) Consistency and State Synchronization

- Agents interacting with **dynamic environments** need consistent state representation.
- Challenges:
  - Concurrent updates in multi-agent systems
  - Synchronizing memory across sessions, devices, or cloud nodes
- Example: Autonomous warehouse agents coordinating inventory levels in real time.

d) Scalability

- Maintaining memory for multiple agents or long histories can become computationally expensive.
- Challenges:
  - Efficient storage and retrieval
  - Latency constraints
  - Balancing memory accuracy with performance
- Example: Real-time trading agents handling millions of transactions daily.

e) Memory Decay and Forgetting

- Agents may need to **forget outdated or irrelevant information** to remain efficient and avoid overfitting.
- Challenge: Designing algorithms for controlled memory decay without losing critical knowledge.
- Example: Forgetting last year's seasonal trends while retaining key patterns for the current year.

f) Integration with External Knowledge

- Agents often rely on external databases, APIs, or knowledge graphs.
- Challenge: Keeping internal state **aligned with external updates** in real time.
- Example: Logistics agents updating delivery schedules based on new shipment data.

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3. Why This Is Critical for Real-World Applications

1. **Maintains Coherence Across Interactions**
   - AI agents must remember prior decisions to avoid repetitive or contradictory actions.
   - Example: Conversational AI recalling user preferences across sessions.
2. **Supports Multi-Step Planning**
   - Many applications involve sequential actions over time.
   - Example: Autonomous factory agents adjusting machine settings step by step.
3. **Enables Personalization**
   - Memory allows agents to provide tailored recommendations or services.
   - Example: Financial AI agents tracking portfolio history to suggest personalized investment strategies.
4. **Improves Safety and Reliability**
   - Proper state management ensures agents **don't take unsafe or inconsistent actions**.

    - Example: Self-driving or manufacturing agents remembering environmental hazards.
5. **Scales to Complex Multi-Agent Systems**
    - Memory synchronization allows multiple agents to collaborate without conflicts.
    - Example: Supply chain agents coordinating inventory, shipping, and production schedules.

Section 2: Case Study Analysis

Case Study: "Smart Manufacturing Implementation at AutoParts Inc."

AutoParts Inc., a mid-sized automotive parts manufacturer, is considering implementing AI Agents across their production facilities. The company faces challenges including:

- 15% defect rate in precision components
- Unpredictable machine downtime causing production delays
- Rising labor costs and difficulty retaining skilled workers
- Increasing customer demands for customization and faster delivery

Your Task:

1. **Propose a comprehensive AI Agent implementation strategy** covering at least three different agent types and their specific roles.
2. **Analyze the expected ROI and implementation timeline** including both quantitative and qualitative benefits.
3. **Identify potential risks and mitigation strategies** focusing on technical, organizational, and ethical considerations.
4. **Simulate your solution on *n8n* or *make.com***

Section 2: Case Study Analysis

Case Study: Smart Manufacturing Implementation at AutoParts Inc.

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1. Comprehensive AI Agent Implementation Strategy

To address AutoParts Inc.'s challenges, the company should deploy a coordinated ecosystem of **three major categories of AI Agents**:

A. Quality Control Agent (Perception + Inspection Agent)

Role: Defect Detection & Root Cause Analysis

Functions:

- Real-time computer vision inspection using high-resolution cameras at each production cell
- Automatically flags defective precision components
- Generates root cause summaries (e.g., tool vibration, temperature drift)
- Sends alerts directly to machine operators
- Continuously learns from defect patterns to improve detection accuracy

Impact:

- Reduces 15% defect rate to 5% or lower
- Increases first-pass yield
- Reduces rework and scrap cost

B. Predictive Maintenance Agent (Machine Health Agent)

Role: Preventing Unplanned Downtime

Functions:

- Analyzes vibration, temperature, power consumption, tool wear
- Predicts machine failure 48–72 hours in advance
- Automatically schedules maintenance with maintenance staff
- Orders spare parts when needed

Impact:

- Reduces sudden machine downtime by 40–60%
- Improves production schedule reliability
- Lowers long-term maintenance cost

C. Production Optimization Agent (Planning + Autonomous Decision Agent)

Role: Coordinating Production Schedules & Resource Allocation

Functions:

- Dynamically adjusts production schedules based on demand
- Optimizes worker allocation based on skill + availability
- Balances machine load across the facility
- Creates customized production sequences for customer-specific parts
- Integrates with ERP and MES systems

Impact:

- Increases output capacity by 20–30%

- Enables rapid customization
- Reduces labor planning inefficiencies

D. Optional: Workforce Assistance Agent (Co-Pilot for Workers)

(Not necessary, but complements workforce retention challenge)

Functions:

- Guides operators through complex tasks
- Provides training videos and troubleshooting steps
- Collects feedback on process issues

Impact: Faster onboarding, lower skill dependency.

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2. Expected ROI & Implementation Timeline

Implementation Timeline (6–12 Months)

Phase	Duration	Activities
1. Assessment & Data Collection	1–2 months	Machine data integration, camera installation, process mapping
2. Agent Development & Testing	2–3 months	Model training, workflow automation, ERP/MES integration
3. Pilot Deployment	2 months	One production line, measure KPIs, operator training
4. Full Rollout	2–4 months	Deploy across all lines, continuous improvement

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Quantitative ROI (12–18 months)

Baseline problem costs:

- Defect rate 15% → annual rework/scrap estimated at ~$2M
- Machine downtime loss ~$1.2M
- Labor inefficiency ~$600K

Estimated Benefits

Benefit	Expected Improvement	Annual Impact
Reduced defects	15% → <5%	~$1.2M savings
Less downtime	40–60% reduction	~$700K savings
Optimized labor utilization	10–15%	~$300K savings
Faster delivery = more orders	+8–12% revenue	~$1–2M gain

Total Annual ROI:

≈ $3.2M – $4.4M total impact

Investment Cost:

- Hardware (cameras, sensors): ~$300K
- AI development + cloud compute: ~$500K
- Integration + Training: ~$150K
  Total ~ $950K

ROI Timeline:

Payback in 6–9 months, depending on production volume.

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3. Risks & Mitigation Strategies

A. Technical Risks

1. Poor Model Accuracy

- **Risk:** AI models perform poorly on noisy factory data
- **Mitigation:**
  - Continuous model retraining
  - High-quality sensor calibration
  - Benchmarked precision cameras

2. System Integration Issues

- **Risk:** MES/ERP integration delays
- **Mitigation:**
  - Use standardized APIs
  - Deploy integration middleware (n8n/Make, Kafka)

B. Organizational Risks

1. Employee Resistance to Automation

- **Mitigation:**
  - Training programs
  - Co-pilot approach (AI supports workers, not replaces)
  - Clear communication of benefits

2. Skill Gaps

- **Mitigation:**
  - Upskill technicians in AI monitoring
  - Provide simple dashboards

C. Ethical Risks

1. Job Displacement Concerns

- **Mitigation:**
  - Transparent workforce transition plan
  - Redeployment to higher-value roles

2. Data Privacy

- **Mitigation:**
  - Strict role-based access
  - Anonymize worker-related data
  - Compliance with ISO 27001

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4. Simulation on n8n or Make.com

Below is a realistic and buildable workflow showing how the AI Agents would function using **n8n** or **Make.com** automation.

A. n8n Simulation (Step-by-Step Workflow)

Workflow: Smart Manufacturing AI Agent Ecosystem

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1. Trigger Node – Machine Data Incoming

- **Trigger:** Webhook, MQTT, or OPC-UA stream from machines

- Data includes:
    - Temperature
    - Vibration
    - Cycle time
    - Error codes

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2. Image Input Node (Quality Camera Feed)

- Connect factory cameras to n8n via:
    - FTP Watcher
    - S3 Bucket Watcher
    - Local file trigger

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3. AI Vision Detection Node (OpenAI Vision or Custom Model)

- Input: Component image
- Output:
    - Defect type
    - Defect probability
    - Coordinates

If defect > threshold → branch to alert operator.

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4. Predictive Maintenance Agent Node

- Python function via n8n Code Node:
    - Extract vibration patterns
    - Predict failure
    - If anomaly → generate ticket

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5. ERP / MES Update Node

- Integrates with:
    - SAP
    - Oracle NetSuite
    - Microsoft Dynamics
    - Odoo

Automatically updates:

- Work orders
- Maintenance schedules
- Inventory levels

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6. Slack/Email Operator Alert Node

Triggers when:

- Defect detected
- Predicted failure
- Low inventory

Message includes:

- Machine ID
- Issue summary
- Recommended action

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7. Dashboard Node (n8n + Google Sheets or Supabase)

Stores real-time logs for:

- Defect rates
- Machine health
- Production utilization

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8. AI Agent for Production Optimization

- Using OpenAI Chat Completion Node
- Inputs: Orders, machine load, labor availability
- Output: Updated schedule
- n8n pushes new schedule to MES

B. Make.com (Make Blueprint Simulation)

Modules in sequence:

1. **Webhook:** Receives machine & camera data
2. **Computer Vision Module:** Detects defects
3. **Data Store:** Logs defect history
4. **AI Model Call (OpenAI):** Predictive maintenance analysis
5. **Router:**

    - If defect → send operator alert
    - If predicted failure → generate maintenance order
6. **ERP Module:** Update manufacturing schedule
7. **Dashboard:** Google Data Studio integration
8. **Loop:** runs every 30 seconds