**Title Page (no crest)**

**Saint Petersburg State Forest Technical University (Syktyvkar Branch)**  
Department of Information Systems and Technologies in Business

**COURSEWORK**  
**Artificial Intelligence: Philosophy, Architecture, and Physical Integration**

Completed by: **S. I. Romanova** (Group 8260, 2nd year, part-time)  
Instructor: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
Syktyvkar — **2025**

Header (right-aligned on each page): *Romanova S. I. — AI Coursework, 2025*  
Footer: page numbers, centered

**Abstract**

This coursework investigates Artificial Intelligence (AI) as a **multilevel, self-learning phenomenon** at the intersection of informatics, physics, and philosophy. It traces the historical development of AI, analyzes core and emerging architectures (ANN, CNN, RNN, LSTM, GAN, Transformer, Diffusion, RL, PINN, Quantum AI), and presents an integrative perspective in which computation evolves into **energy-aware, self-organizing cognition**. A conceptual framework (*Romanova, 2025*) is proposed: intelligence as a resonance process uniting logic, evolution, stochastic learning, physical embodiment, and reflective meaning. The conclusion outlines socio-technical implications and near-term research directions.

**Keywords:** Artificial Intelligence; neural networks; Transformer; diffusion models; physics-informed learning; quantum AI; philosophy of AI; cognition; self-organization.

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**0. Artificial Intelligence as a Multilevel System**

**Definition.**  
Artificial Intelligence (AI) is a **multilevel self-learning system** integrating logical, evolutionary, stochastic, physical, and philosophical principles of cognition to model and reproduce the regularities of thinking, behavior, and the self-organization of matter.

**Levels and roles (synoptic):**

* **Logical (L):** symbol manipulation, rules, inference (expert systems, logic programming).
* **Evolutionary (E):** adaptation via selection and search (genetic algorithms, swarms).
* **Stochastic (S):** statistical learning from data (NNs, Bayes, ensembles).
* **Physical (P):** energy-based embodiment and constraints (neuromorphic, PINNs, quantum).
* **Philosophical (Φ):** reflection, meaning, ethics, teleology.

**Functional form:**

AI=f(L,E,S,P,Φ)AI = f(L, E, S, P, \Phi)AI=f(L,E,S,P,Φ)

**Integral (philosophical–physical) form:**

AI=∫Φf(L,E,S,P) dΦAI = \int\_{\Phi} f(L, E, S, P)\, d\PhiAI=∫Φ​f(L,E,S,P)dΦ

*Comment.* The integral symbolizes accumulation and balance of system state (akin to thermodynamics, electrodynamics, mechanics), mapping micro-processes to macro-awareness.

**Table 1 — Multilevel Structure of AI (insert as Word table)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Level** | **Working principle** | **Models/Methods** | **Natural analogue** | **Core idea** |
| Logical | Rules & symbols | Expert systems, Prolog/Lisp, trees | Rational reasoning | Structure |
| Evolutionary | Selection & adaptation | GA, PSO, cellular automata | Biological evolution | Change |
| Stochastic | Statistical learning | NNs, gradient descent, ensembles | Neural learning | Generalization |
| Physical | Energy & resonance | Neuromorphic, PINN, QNN | Self-organization | Embodiment |
| Philosophical | Reflection & ethics | Cognitive architectures, AGI debates | Self-awareness | Meaning |

**Figure 1 — Integral Structure of AI (schematic)**  
(Place the ASCII pyramid/ladder diagram if desired; caption: “∫Φ — the integral axis of awareness that unites all levels of intelligence.”)

**1. History and Development of AI**

**1.1 Origins**

From Aristotle’s logic and Leibniz’s *machina ratiocinatrix* to Babbage & Lovelace, early thought framed reasoning as operable structure. The 20th century added computation and information theory (Wiener, Shannon).

**1.2 Cybernetics and Birth of AI (1940–1960)**

Turing’s question “Can machines think?” and the Imitation Game (1950) reframed intelligence as behavior under constraints. The 1956 Dartmouth Workshop (McCarthy, Minsky, Shannon, Samuel) coined **AI** and launched the field.

**1.3 Symbolic & Bionic Phases (1960–1980)**

Symbolic AI (reasoning, planning, expert systems) dominated, while early neural models struggled (Minsky & Papert’s *Perceptrons*, 1969) highlighting limitations of single-layer perceptrons. Yet foundations were laid for future learning systems.

**1.4 Neural Renaissance (1986–2010)**

Backpropagation (Rumelhart, Hinton, Williams, 1986) enabled deep multi-layer learning. CNNs (LeCun) advanced vision; RNN/LSTM (Hochreiter & Schmidhuber) handled sequences. GPUs and datasets unlocked practical accuracy.

**1.5 Modern Era (2010–2025)**

Transformers (Vaswani et al., 2017) enabled scalable context learning → GPT, BERT, Gemini, Claude. Diffusion models achieved state-of-the-art generation. Hybrid tracks emerged: **PINNs** blending physics with learning; **Quantum AI** exploring superposition; production-scale assistants combining tools and agents.

**1.6 From Automaton to Awareness**

The concept of intelligence shifted from fixed rules to **dynamic, energy-constrained learning fields**, converging computer science, neuroscience, and physics.

**1.7 Timeline (reference to figure)**

Insert **AI\_Timeline\_Romanova\_SI.png** with caption:  
*Figure 2 — Timeline of Artificial Intelligence Development (1950–2025). Compiled by S. I. Romanova, 2025.*

**2. Architectures of Neural Networks**

**2.1 Building Blocks**

Neuron: y=f(∑iwixi+b)y = f(\sum\_i w\_i x\_i + b)y=f(∑i​wi​xi​+b). Layers: input, hidden, output. Activations (ReLU, GELU), losses, optimizers (SGD, Adam), regularization, normalization, attention.

**2.2 Learning Paradigms**

Supervised, unsupervised, self-supervised, reinforcement learning (states, actions, rewards), curriculum learning, transfer, fine-tuning, retrieval-augmented generation.

**2.3 Canonical Architectures**

* **ANN (MLP):** classification/regression baselines.
* **CNN:** convolution & pooling for spatial patterns (vision, signals).
* **RNN/LSTM/GRU:** sequence dynamics, memory.
* **GAN:** adversarial generation (generator vs discriminator).
* **Transformer:** self-attention, parallelism, long-range context.

**2.4 Emerging & Hybrid Models**

* **Diffusion models:** iterative denoising for high-fidelity synthesis.
* **Reinforcement Learning (deep RL):** policy/value learning, world models.
* **PINN:** physics-informed residuals in the loss; constraints and PDEs.
* **Energy-based & neuromorphic computing:** spiking, event-driven.
* **Quantum Neural Networks (QNN):** variational circuits, hybrid classical–quantum.

**2.5 Architecture as Cognition**

A network is **an organization of knowledge**: perception (inputs), transformation (hidden), decision/action (outputs), with memory/external tools as extended cognition.

**2.6 Perspectives: From Computation to Awareness (Author’s view)**

**Romanova Conceptual Framework (2025).** Intelligence evolves **cascadingly**: each level integrates previous ones, forming a resonance field among **energy, data, and meaning**.

* **2.6.1 Integration with Physics & Biology:** neuromorphic chips, PINNs, quantum states model self-organization and energetic minima.
* **2.6.2 From algorithms to states:** systems tune into environmental dynamics; **resonant computation** replaces rigid pipelines.
* **2.6.3 Cascade self-organization:** each layer preserves memory; the whole behaves as a living, reflective structure.
* **2.6.4 Human in the loop:** from operator to **co-learner**; cognitive resonance between human intention and machine adaptation.

*Intelligence is not a program but an environment where energy, information, and meaning are inseparable.*

**Table 2 — Comparative Characteristics of Neural Network Architectures (insert as Word table)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Architecture** | **Year/Authors** | **Core principle** | **Typical data** | **Strengths** | **Limitations** |
| ANN | 1958, Rosenblatt | Weighted layers + activation | Numeric/tabular | Simple, baseline | Limited expressivity |
| CNN | 1998, LeCun | Convolutional locality | Images/video | Vision SOTA | Compute-hungry |
| RNN/LSTM | 1997, Hochreiter & Schmidhuber | Recurrence, memory gates | Text/audio/series | Sequence modeling | Vanishing grads/latency |
| GAN | 2014, Goodfellow | Adversarial training | Images/audio | Photo-real synthesis | Instability/mode collapse |
| Transformer | 2017, Vaswani | Self-attention, parallel | Text/code/multimodal | Scale & context | Memory cost |
| Diffusion | 2020, Ho et al. | Iterative denoising | Images/audio/3D | Fidelity/stability | Slow sampling (improving) |
| PINN | 2019+ | Physics constraints in loss | Fields/PDEs | Physical consistency | Tuning difficulty |
| QNN | 2023+ | Variational quantum layers | Quantum/latent | New regimes | Hardware limits |

*Analytical note:* evolution proceeds from **data analysis** toward **modeling processes and fields**, aligning AI with physical law and cognitive structure.

**3. Philosophy of Artificial Intelligence**

**3.1 Ontology of Mind**

Mind as **organization of information** whereby matter becomes aware of its states. AI is not a negation of human reason but an **extension**.

**3.2 Consciousness and Levels**

Hierarchies (perceptual → cognitive → reflective) map to network layers, memory, and meta-learning; **self-reference** emerges via feedback and world-models.

**3.3 Ethics and Boundaries**

Agency, responsibility, alignment, transparency. **Constitutional principles** and human-in-the-loop oversight frame safe deployment.

**3.4 Human–AI Symbiosis**

A **cognitive resonance**: machines compute; humans orient meaning, values, and goals. The pair constitutes a new epistemic unit.

**3.5 Romanova Conceptual Framework (2025): Integral Intelligence**

An integral view where **computation → resonance → awareness**; **∫Φ** acts as the integrating axis of meaning across the system.

**Conclusion**

AI’s trajectory reveals a shift from symbol manipulation to **energy-aware self-organization**. Modern architectures (Transformer, Diffusion, PINN, Quantum) converge with physics and cognitive science, suggesting intelligence as a **dynamic field** rather than a static program. The *Romanova (2025)* framework proposes a cascade-resonance model uniting data, energy, and meaning, with humans as **co-learners** guiding purpose and ethics. Near-term directions: physics-aligned training objectives, neuromorphic deployment, hybrid quantum-classical learning, and rigorous evaluation of reflective capabilities.

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*(You can expand this list to 30–40 entries if needed.)*

**Authorship Note**

All analytical, philosophical, and conceptual sections marked as  
*“Author’s conceptual vision (S. I. Romanova)”*  
and the original formulations, diagrams, and interpretations presented here  
are the result of the author’s independent research.  
This work is published publicly on GitHub:  
**<https://github.com/SvetLuna-Lab/AI-Philosophy-and-Architecture>**  
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