

# ARYABHATA: AN EXAM-FOCUSED LANGUAGE MODEL FOR JEE MATH

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## ABSTRACT

We present **Aryabhata 1.0**, a compact 7B parameter math reasoning model optimized for the Indian academic exam, the Joint Entrance Examination (JEE). Despite rapid progress in large language models (LLMs), current models often remain unsuitable for educational use. Aryabhata 1.0 is built by merging strong open-weight reasoning models, followed by supervised fine-tuning (SFT) with curriculum learning on verified chain-of-thought (CoT) traces curated through best-of- $n$  rejection sampling. To further boost performance, we apply reinforcement learning with verifiable rewards (RLVR) using A2C objective with group-relative advantage estimation along with novel exploration strategies such as *Adaptive Group Resizing* and *Temperature Scaling*. Evaluated on both in-distribution (JEE Main 2025) and out-of-distribution (MATH, GSM8K) benchmarks, Aryabhata outperforms existing models in accuracy and efficiency, while offering pedagogically useful step-by-step reasoning. We release Aryabhata as a foundation model to advance exam-centric, open-source small language models..

## 1 INTRODUCTION

Large language models (LLMs) have shown remarkable progress in mathematical reasoning, but most existing systems fall short in supporting student learning in academic settings like India’s Joint Entrance Examination (JEE). These exams require not only accurate solutions but also transparent and precise reasoning that aids student understanding and long-term learning.

We observe three broad classes of models in this space:

**Non-reasoning models** Instruction-tuned models (e.g., GPT-4o) were largely inaccurate on rigorous math exams like JEE. These models failed to perform multi-step reasoning, often guessing answers or relying on shallow pattern matching.

**Early reasoning models** introduced long chain-of-thought (CoT) reasoning to improve accuracy, with examples including OpenAI o1 (OpenAI, 2024) and DeepSeek R1 (DeepSeek-AI et al., 2025). While these models were more accurate than non-reasoning baselines, they remained impractical in real-world educational settings. For instance, o1 (OpenAI, 2024) did not expose its reasoning trace and provided just a summary of them, while DeepSeek R1 (DeepSeek-AI et al., 2025) produced long, nonlinear traces that made it difficult for students to follow the logic. Moreover, both models were relatively slow, generating lengthy explanations that consumed a significant amount of tokens and latency.

**Modern reasoning models** such as OpenAI o4-mini (OpenAI, 2025), Gemini 2.5 (Comanici et al., 2025), and the updated version of DeepSeek R1 (DeepSeek-AI et al., 2025) have improved further in raw accuracy and generation speed. However, pedagogical usability remains limited. For example, o4-mini (OpenAI, 2025) provides just a summary of its reasoning traces, while Gemini (Comanici et al., 2025) and DeepSeek R1 (DeepSeek-AI et al., 2025) still produce nonlinear, self-correcting reasoning paths that confuse learners rather than clarify concepts. (Samples are provided in Appendix D.)

In this work, we present **Aryabhata 1.0**, a compact and open 7B parameter model tailored for math reasoning in Indian competitive exams. Built via model merging and fine-tuned with domain-aligned data, Aryabhata combines accuracy, transparency, and efficiency, making it a viable foundation for educational AI applications.

## 2 RELATED WORK

Current math LLMs built on open-weight backbones have primarily leveraged Imitation Learning, Supervised Fine Tuning, and Reinforcement Learning to enhance chain-of-thought mathematical reasoning.

For instance **DeepSeekMath** (Shao et al., 2024), introduced in early 2024, advanced the capabilities of open weight models by pre-training on hundreds of billions of math-focused tokens and pioneering Group Relative Policy Optimization (GRPO).

**Qwen-2.5-Math-7B** (Yang et al., 2024) is a math-specialized 7B instruction-tuned model that supports chain-of-thought (CoT) and tool-integrated reasoning (TIR) across both English and Chinese problem sets.

NVIDIA’s **AceMath-7B-Instruct** (Liu et al., 2025a), derived from Qwen, advances its performance further through a multi-stage SFT training pipeline designed to improve both mathematical and reasoning accuracy on multiple benchmarks and edging close to much larger models at 72B scale.

Meanwhile, **DeepSeek-R1** (DeepSeek-AI et al., 2025) introduced a pure RL-based reasoning model trained with GRPO-style verifiable rewards, achieving impressive results. Its distilled variants (**DeepSeek-R1-Distill-Qwen-7B** (DeepSeek-AI et al., 2025)) inherit reasoning performance via long CoT.

The **AceReason-Nemotron-7B** (Liu et al., 2025a) demonstrates that large-scale reinforcement learning can significantly enhance the reasoning capabilities of strong small- and mid-sized models by first training on math-only prompts, then on code-only prompts.

The **AceReason-Nemotron-1.1-7B** (Liu et al., 2025b) synergizes SFT and RL fine-tuning by employing a stage-wise RL approach on math-only and code-only prompts.

Our approach builds on these lines by merging models for hybrid capabilities (symbolic fluency + coherent CoT), followed by rejection-sampled SFT and RL with verifiable rewards, preserving both performance and efficiency in a compact model.

## 3 METHODOLOGY

The overall process can be categorized in the following four stages:

### 3.1 MODEL MERGING

The development of LLMs has seen a transition from System 1 (quick thinking) to System 2 (deliberate, methodical) reasoning, each with distinct advantages (Wu et al., 2025). While System 1 models excel at producing fluent answers with low latency, they often lack the depth required for complex reasoning. In contrast, System 2 models are capable of iterative self-correction and structured reasoning, but suffer from inefficiencies due to verbose or redundant CoT traces.

To address this challenge, Kimi k1.5 (Team et al., 2025) introduced the concept of merging reasoning and non-reasoning models, which was further explored by Wu et al. (2025). Building on this intuition, we carefully selected three distinct LLMs, each sharing the same base architecture.

- Qwen2.5-Math-7B-Instruct (Yang et al., 2024), a strong open source mathematical LLM providing solid baseline capabilities and fundamental math fluency.
- AceMath-7B-Instruct (Liu et al., 2025a) a version of Qwen 2.5 Math that was further fine-tuned by NVIDIA, significantly enhancing its accuracy on mathematical benchmarks.
- DeepSeek-R1-Distill-Qwen-7B (DeepSeek-AI et al., 2025), a long-form reasoning model derived by fine-tuning Qwen 2.5 Math on reasoning traces distilled from DeepSeek R1 (DeepSeek-AI et al., 2025).

We apply linear merging (Wortsman et al., 2022) to combine the models using the MergeKit (Goddard et al., 2024) framework.

Let  $\theta_1, \theta_2, \theta_3$  be the parameters of Qwen, Ace, and DeepSeek, respectively. We compute:

$$\theta_{\text{merged}} = \alpha\theta_1 + \beta\theta_2 + \gamma\theta_3, \quad \text{where } \alpha + \beta + \gamma = 1$$

We select weights  $\alpha, \beta, \gamma$  empirically based on the held-out math reasoning tasks. Final weights favor quickly addressing simpler problems while also performing methodical, multi-step analysis for more complex mathematical challenges.

Table 1: Topic-wise Question Distribution

Topic	%age
Application of Derivatives	4.50%
Application of Integrals	2.27%
Binomial Theorem	2.37%
Circles	2.85%
Complex Numbers & Quadratic Equations	6.00%
Conic Section	7.55%
Continuity and Differentiability	2.71%
Definite Integration	2.45%
Determinants	3.04%
Differential Equations	3.77%
Indefinite Integration	3.26%
Inverse Trigonometric Functions	5.31%
Limits and Derivatives	3.88%
Matrices	2.46%
Permutations and Combinations	4.23%
Probability	5.69%
Quadratic Equations	4.45%
Relations and Functions	2.24%
Sequence and Series	2.75%
Sets	1.04%
Statistics	1.89%
Straight Lines	2.31%
Three Dimensional Geometry	3.92%
Trigonometric Functions	4.51%
Vector Algebra	2.89%
Miscellaneous	11.65%

### 3.2 DATA CURATION

High-quality, domain-aligned data is essential for training effective mathematical reasoning models. To this end, we relied on a proprietary corpus curated by our subject matter experts and educators, ensuring close alignment with the Indian Joint Entrance Examination (JEE) standards. This dataset represents years of academic effort and is considered our core intellectual property. As such, we do not publicly release the training data.

We parsed approximately 250,000 raw questions from internal databases. To ensure syntactic coherence and semantic relevance, we applied the following filtering steps:

- Removed diagram-based questions, which require multimodal reasoning not supported by current text-only models.
- Filtered out non-English or poorly formatted questions.
- Stripped all answer options from the remaining questions to frame the task as open-ended generation rather than classification. This design choice was also explored by Chandak et al. (2025)
- Since we stripped options from the questions, we removed the questions which relied on options to be answered such as "which of the following is true"

Table 2: Chain-of-Thought generation outcomes from best-of-4 sampling.

Correct CoTs	# Questions	Total CoTs	Usage
0	31,470	0	Used in RLVR only
1	9,647	9,647	SFT
2	9,066	18,132	SFT
3	12,643	37,929	SFT
4	67,247	268,988	10% sampled for SFT

To standardize and clean raw question-answer pairs, we designed a structured prompt (see Appendix A) that extracts the core question, normalizes the answer format, identifies dependencies and detects the question language, using OpenAI o4-mini.

This process resulted in a clean dataset of around 130,000 questions suitable for the generation of further chain of thought. The topic-wise distribution of questions is outlined in Table 1.

### 3.3 SUPERVISED FINE-TUNING WITH REJECTION SAMPLING

To generate high-quality chain-of-thought (CoT) supervision, we employed best-of-4 rejection sampling using the merged model. For each curated question  $x$ , we sampled four CoT responses  $\{y_1, y_2, y_3, y_4\}$ , and selected only those completions whose final answer matched the known correct answer i.e.  $GT(x)$ , using Algorithm 4. This filtering process ensures logical correctness and minimizes noisy supervision signals.

We then grouped the questions based on how many of the four generations lead to the correct answers and selected samples for curriculum-style supervised fine-tuning (Bengio et al., 2009), i.e., beginning the training with easier samples (e.g., 4/4 correct) and gradually introducing harder examples (e.g., 3/4, 2/4, 1/4 correct). This curriculum-based training stabilizes early learning and improves generalization on harder problems.

Let  $\mathcal{D}_{\text{sft}} = \{(x^{(i)}, y^{(i)})\}_{i=1}^N$  denote the dataset of input questions and their corresponding verified CoT completions. The supervised fine-tuning objective minimizes the standard next-token prediction loss:

$$\mathcal{L}_{\text{SFT}} = - \sum_{(x,y) \in \mathcal{D}_{\text{sft}}} \sum_{t=1}^T \log(p_{\theta}(y_t | x, y_{<t})) \quad (1)$$

where  $y_t$  is the  $t^{\text{th}}$  token of the target CoT sequence, and  $p_{\theta}$  is the model’s probability distribution parameterized by  $\theta$ .

In total, we obtained approximately 350,000 verified CoTs across around 100,000 questions, which were sampled to serve as the core training corpus for SFT, as detailed in Table 2. The 0/4 cases were retained for downstream reinforcement learning with verifiable rewards (RLVR) to further improve coverage and robustness in challenging problem spaces.

We used Parameter Efficient Finetuning, particularly Low-Rank Adaptation (Hu et al., 2021) during SFT using peft (Mangrulkar et al., 2022) library, the training parameters are mentioned in Appendix C.

### 3.4 REINFORCEMENT LEARNING WITH VERIFIABLE REWARDS

We extend Reinforcement Learning with Verifiable Rewards (RLVR) (Lambert et al., 2025) by incorporating group-based advantage estimation (Shao et al., 2024) within an Advantage Actor-Critic (A2C) framework (Mnih et al., 2016).

#### 3.4.1 GROUP-RELATIVE POLICY OPTIMIZATION

Our approach optimizes the following A2C objective with group-relative advantage estimation:

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$$J^{A2C}(\theta) = \mathbb{E}(\alpha_i) \sim \pi\theta \left[ \frac{1}{G} \sum_{i=1}^G \frac{1}{|\alpha_i|} \log \pi_\theta(\alpha_i) \cdot \tilde{A}_i \right]$$

We optimize the A2C objective over  $G$  sampled response sequences  $\alpha_i$ , applying length-normalized gradients weighted by sequence-level advantages  $\tilde{A}_i$  computed through group-relative advantage estimation.

**Binary Reward Structure:** We employ a simple binary reward that provides unambiguous feedback for mathematical reasoning:

$$R_i = \begin{cases} 1 & \text{if the final answer is correct} \\ 0 & \text{if the final answer is incorrect} \end{cases}$$

**Group Advantage Estimation** The advantage function is computed using group-relative normalization:

$$\hat{A}_{i,t} = \frac{R_i - \bar{R}_{\text{group}}}{\sigma_{\text{group}}}$$

where  $\bar{R}_{\text{group}}$  is the mean reward across all solutions in the group and  $\sigma_{\text{group}}$  is the standard deviation.

**Key Benefits:** This group-relative baseline offers several advantages:

- **Reduced variance:** Group comparison stabilizes gradient estimates
- **Simplified training:** Eliminates need for KL divergence constraints or probability ratio clipping
- **Natural compatibility:** Works seamlessly with binary rewards, common in mathematical reasoning tasks

### 3.4.2 EXPLORATION STRATEGIES

**Adaptive Group Sizing:** Unlike fixed group sizes in standard GRPO implementations (von Werra et al. (2020), Sheng et al. (2024), Daniel Han & team (2023)), we dynamically adjust group size based on problem difficulty. Starting with a group size of 8 for simpler problems, we scale up to a group size of 64 for harder ones.

The dynamic group size follows:

$$G_d = 8 \times 2^k$$

where  $k \in \{0, 1, 2, 3\}$  is determined by the group average reward  $\bar{R}_{\text{group}}$ . When performance drops below preset thresholds, we increase  $k$ , scaling groups as:  $8 \rightarrow 16 \rightarrow 32 \rightarrow 64$ .

This adaptive scaling improves sampling diversity and advantage estimation stability for challenging problems while efficiently allocating computational resources.

**Progressive Temperature Scaling:** We continuously increase the sampling temperature from 0.6 to 1.0 throughout training, this was explored in contemporary works like POLARIS (An et al., 2025). This progressive scaling balances exploitation and exploration:

- **Initial phase:** Low temperature (0.6) promotes training stability through conservative sampling
- **Progressive increase:** Temperature gradually rises, encouraging more diverse solution exploration
- **Final phase:** Temperature reaches 1.0, enabling much more exploration of the action space compared to lower temperatures.

**Curriculum-Based Sampling:** We filter training samples to focus on an optimal difficulty range, removing both trivial and intractable problems:

- **Too easy:** Provide minimal learning signal due to high success rates
- **Too hard:** Introduce noise through consistently low performance

Our filtering uses a difficulty assessment function  $f_{\text{difficulty}}(x)$  based on model success rates:

$$\mathcal{D}_t^{\text{filtered}} = \{x \in \mathcal{D}_t : \alpha_{\min} \leq f_{\text{difficulty}}(x) \leq \alpha_{\max}\}$$

This curriculum approach concentrates computational resources on problems that maximize learning progress.

### 3.4.3 HARDWARE-OPTIMIZED ALTERNATING INFERENCE-TRAINING PIPELINE

To maximize computational resource utilization and overcome GPU memory constraints inherent in large-scale reinforcement learning training, we implement an alternating synchronized rollout strategy that decouples the inference and training phases into discrete, non-overlapping computational cycles.

Our approach leverages vLLM (Kwon et al., 2023) as the primary inference engine for rollout generation. The training pipeline operates according to the following synchronized cycle:

#### Phase 1: Rollout Generation

- vLLM inference engine is created
- Batch rollout generation is performed across all training samples
- Generated rollouts are serialized and stored in system memory
- vLLM process is destroyed and releases all GPU memory allocations

#### Phase 2: Policy Optimization

- Training model is loaded onto GPU memory with full memory availability
- Policy gradient updates are computed using stored rollouts
- Model parameters are updated and checkpointed
- Training model is offloaded to memory
- vLLM process is restarted for subsequent rollout generation

This alternating architecture provides several critical advantages: **(1) Memory Efficiency:** Complete GPU memory is available to each phase, enabling larger batch sizes and model configurations than would be possible with concurrent inference-training approaches. **(2) Training Stability:** Deterministic separation of inference and training phases eliminates potential race conditions and memory fragmentation issues.

### 3.4.4 TRAINING CONFIGURATION AND HYPERPARAMETERS

Our reinforcement learning implementation employs carefully tuned hyperparameters optimized for mathematical reasoning tasks while maintaining computational efficiency within hardware constraints. The training configuration incorporates modern optimization techniques and memory-efficient strategies to enable stable convergence at scale.

**Optimization Configuration:** We utilize the Adam optimizer (Kingma & Ba, 2017) with a conservative learning rate of  $1 \times 10^{-6}$  to ensure stable policy gradient updates throughout the training process.

**Memory and Precision Management:** Training is conducted using bfloat16 (BF16) mixed precision arithmetic, which provides substantial memory savings while maintaining numerical stability for gradient computations. Gradient checkpointing is employed to further reduce memory consumption during backpropagation, enabling training of larger models within available GPU memory constraints.

**Sequence and Batch Configuration:** The model operates within a maximum context length of 4,096 tokens, providing sufficient capacity for complex multi-step mathematical reasoning while maintaining computational tractability.

## 4 EVALUATION

We evaluated Aryabhata 1.0 across both in-distribution and out-of-distribution math benchmarks to assess its accuracy and efficiency in solving problems at scale.

We evaluate model-generated solutions using the `pass@1` accuracy. The solutions are generated using greedy decoding (temperature = 0). To determine whether a predicted answer matches the ground-truth answer for a question, we follow the pipeline described in the Algorithm 4.

**Answer Matching Procedure [1]** **Input:** Predicted answer  $a_p$ , Ground-truth answer  $a_g$ , Options (if any) **Output:** Match status (True / False)

$a_p = a_g$  or `sympy_latex_match(a_p, a_g)` True option/identifier from  $a_p ==$  option/identifier from  $a_g$   
 True Query LLM judge with  $a_p, a_g$ , and options (if any) LLM returns YES True False

Depending on whether the question is Multiple Choice Question or a Numerical Answer Type, we use different prompts to query the judge model (GPT-4o-mini). The prompts are provided in Table 4.

### 4.1 IN-DISTRIBUTION EVALUATION: JEE MAIN 2025

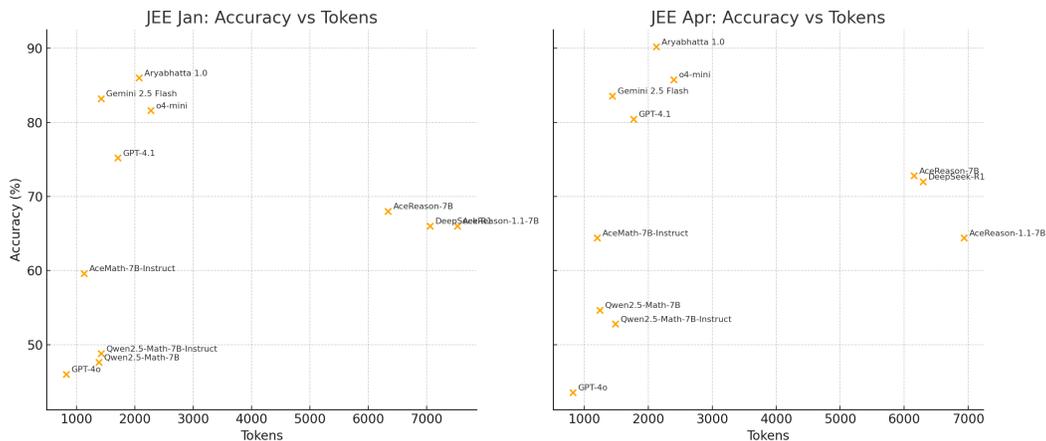


Figure 1: Scatter plots showing Accuracy vs. Tokens for JEE Jan and JEE Apr.

Table 3: Performance comparison on MATH 500 and GSM8K benchmarks

Model	MATH 500	GSM8K
Aryabhata 1.0	83.6	94.8
Qwen/Qwen2.5-Math-7B-Instruct	66.0	94.7
nvidia/AceMath-7B-Instruct	80.6	93.4
GPT-4o	69.2	94.6
deepseek-ai/DeepSeek-R1-Distill-Qwen-7B	85.2	69.7
nvidia/AceReason-Nemotron-7B	84.2	76.5
nvidia/AceReason-Nemotron-1.1-7B	85.4	93.1
GPT-4.1	86.6	94.0
o4-mini	94.8	90.1
Gemini 2.5 Flash	93.6	85.1

To measure performance in familiar distribution settings, we evaluate Aryabhata on the JEE Main 2025 exam. The January session contains 250 questions (10 papers with 25 questions each), while

the April session comprises 225 questions (9 papers with 25 questions each), all sourced from official exam papers.

Figure 1 shows that Aryabhata 1.0 achieves an accuracy of **86.0%** on the January session and **90.2%** on the April session, while maintaining token efficiency with an average of approximately  $\sim$ 2K tokens per response.

Compared to both open-weight and proprietary models, Aryabhata outperforms all baselines in accuracy while remaining competitive in inference cost.

#### 4.2 OUT-OF-DISTRIBUTION EVALUATION

To evaluate generalization beyond the fine-tuning distribution, we benchmark Aryabhata 1.0 on the following datasets:

- **MATH 500**: A curated benchmark of 500 competition-style problems drawn from the larger MATH dataset originally introduced by Hendrycks et al. (2021).
- **GSM8K** (Cobbe et al., 2021): A widely used benchmark of grade school math word problems.

Table 3 shows that Aryabhata demonstrates **competitive generalization** to unseen tasks of comparable difficulty, outperforming its base models on both MATH and GSM8K.

## CONCLUSION AND FUTURE WORK

In this work, we introduced **Aryabhata 1.0**, a compact open source model with 7B parameters for mathematical reasoning, specifically designed for the Indian competitive exam ecosystem. By merging diverse mathematical LLMs and fine-tuning on carefully curated and verified domain-specific data, Aryabhata achieves state-of-the-art performance on in-distribution benchmarks such as JEE Main, while demonstrating competitive generalization to out-of-distribution tasks like MATH and GSM8K.

Looking ahead, we plan to: Expand coverage to Physics and Chemistry, building similar reasoning capabilities in other STEM domains. Scale to the full syllabus across Foundation, JEE (Main & Advanced), and NEET, enabling end-to-end subject-level assistance. Develop a family of exam-centric, open source small language models (SLMs) that are compact, efficient, and aligned to Indian education standards.

We believe that this direction will empower millions of students with accessible and curriculum-aligned AI tools that complement classroom learning and personalized preparation.

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476 Lacey, Craig Schiff, Sebastien Baur, Sanjay Ganapathy, Eva Schneider, Mateo Wirth, Connor  
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479 Sun, Ananth Balashankar, Kurt Shuster, Megh Umekar, Mahmoud Alnahlawi, Aaron van den  
480 Oord, Kelly Chen, Yuexiang Zhai, Zihang Dai, Kuang-Huei Lee, Eric Doi, Lukas Zilka, Rohith  
481 Vallu, Disha Shrivastava, Jason Lee, Hisham Husain, Honglei Zhuang, Vincent Cohen-Addad,  
482 Jarred Barber, James Atwood, Adam Sadosky, Quentin Wellens, Steven Hand, Arunkumar Ra-  
483 jendran, Aybuke Turker, CJ Carey, Yuanzhong Xu, Hagen Soltau, Zefei Li, Xinying Song, Con-  
484 glong Li, Iurii Kemaev, Sasha Brown, Andrea Burns, Viorica Patraucean, Piotr Stanczyk, Renga  
485 Aravamudhan, Mathieu Blondel, Hila Noga, Lorenzo Blanco, Will Song, Michael Isard, Mandar  
Sharma, Reid Hayes, Dalia El Badawy, Avery Lamp, Itay Laish, Olga Kozlova, Kelvin Chan,  
Sahil Singla, Srinivas Sunkara, Mayank Upadhyay, Chang Liu, Aijun Bai, Jarek Wilkiewicz,  
Martin Zlocha, Jeremiah Liu, Zhuowan Li, Haiguang Li, Omer Barak, Ganna Raboshchuk, Jiho  
Choi, Fangyu Liu, Erik Jue, Mohit Sharma, Andreea Marzoca, Robert Busa-Fekete, Anna Ko-  
rsun, Andre Elisseeff, Zhe Shen, Sara Mc Carthy, Kay Lamerigts, Anahita Hosseini, Hanzhao

486 Lin, Charlie Chen, Fan Yang, Kushal Chauhan, Mark Omernick, Dawei Jia, Karina Zainul-  
487 lina, Demis Hassabis, Danny Vainstein, Ehsan Amid, Xiang Zhou, Ronny Votel, Eszter Vértés,  
488 Xinjian Li, Zongwei Zhou, Angeliki Lazaridou, Brendan McMahan, Arjun Narayanan, Hubert  
489 Soyer, Sujoy Basu, Kayi Lee, Bryan Perozzi, Qin Cao, Leonard Berrada, Rahul Arya, Ke Chen,  
490 Katrina, Xu, Matthias Lochbrunner, Alex Hofer, Sahand Sharifzadeh, Renjie Wu, Sally Gold-  
491 man, Pranjal Awasthi, Xuezhi Wang, Yan Wu, Claire Sha, Biao Zhang, Maciej Mikula, Filippo  
492 Graziano, Siobhan Mcloughlin, Irene Giannoumis, Youhei Namiki, Chase Malik, Carey Rade-  
493 baugh, Jamie Hall, Ramiro Leal-Cavazos, Jianmin Chen, Vikas Sindhwani, David Kao, David  
494 Greene, Jordan Griffith, Chris Welty, Ceslee Montgomery, Toshihiro Yoshino, Liangzhe Yuan,  
495 Noah Goodman, Assaf Hurwitz Michaely, Kevin Lee, KP Sawhney, Wei Chen, Zheng Zheng,  
496 Megan Shum, Nikolay Savinov, Etienne Pot, Alex Pak, Morteza Zadimoghaddam, Sijal Bhat-  
497 nagar, Yoad Lewenberg, Blair Kutzman, Ji Liu, Lesley Katzen, Jeremy Selier, Josip Djolonga,  
498 Dmitry Lepikhin, Kelvin Xu, Jacky Liang, Jiewen Tan, Benoit Schillings, Muge Ersoy, Pete  
499 Blois, Bernd Bandemer, Abhimanyu Singh, Sergei Lebedev, Pankaj Joshi, Adam R. Brown,  
500 Evan Palmer, Shreya Pathak, Komal Jalan, Fedir Zubach, Shuba Lall, Randall Parker, Alok Gun-  
501 jan, Sergey Rogulenko, Sumit Sanghai, Zhaoqi Leng, Zoltan Egyed, Shixin Li, Maria Ivanova,  
502 Kostas Andriopoulos, Jin Xie, Elan Rosenfeld, Auriel Wright, Ankur Sharma, Xinyang Geng,  
503 Yicheng Wang, Sam Kwei, Renke Pan, Yujing Zhang, Gabby Wang, Xi Liu, Chak Yeung, Eliz-  
504 abeth Cole, Aviv Rosenberg, Zhen Yang, Phil Chen, George Polovets, Pranav Nair, Rohun Sax-  
505 ena, Josh Smith, Shuo yin Chang, Aroma Mahendru, Svetlana Grant, Anand Iyer, Irene Cai,  
506 Jed McGiffin, Jiaming Shen, Alanna Walton, Antonious Girgis, Oliver Woodman, Rosemary Ke,  
507 Mike Kwong, Louis Rouillard, Jinneng Rao, Zhihao Li, Yuntao Xu, Flavien Prost, Chi Zou,  
508 Ziwei Ji, Alberto Magni, Tyler Liechty, Dan A. Calian, Deepak Ramachandran, Igor Krivokon,  
509 Hui Huang, Terry Chen, Anja Hauth, Anastasija Ilić, Weijuan Xi, Hyeontaek Lim, Vlad-Doru  
510 Ion, Pooya Moradi, Metin Toksoz-Exley, Kalesha Bullard, Miltos Allamanis, Xiaomeng Yang,  
511 Sophie Wang, Zhi Hong, Anita Gergely, Cheng Li, Bhavishya Mittal, Vitaly Kovalev, Victor Un-  
512 gureanu, Jane Labanowski, Jan Wassenberg, Nicolas Lacasse, Geoffrey Cideron, Petar Dević,  
513 Annie Marsden, Lynn Nguyen, Michael Fink, Yin Zhong, Tatsuya Kiyono, Desi Ivanov, Sally  
514 Ma, Max Bain, Kiran Yalasang, Jennifer She, Anastasia Petrushkina, Mayank Lunayach, Carla  
515 Bromberg, Sarah Hodkinson, Vilobh Meshram, Daniel Vlasic, Austin Kyker, Steve Xu, Jeff Stan-  
516 way, Zuguang Yang, Kai Zhao, Matthew Tung, Seth Odoom, Yasuhisa Fujii, Justin Gilmer,  
517 Eunyoung Kim, Felix Halim, Quoc Le, Bernd Bohnet, Seliem El-Sayed, Behnam Neyshabur,  
518 Malcolm Reynolds, Dean Reich, Yang Xu, Erica Moreira, Anuj Sharma, Zeyu Liu, Moham-  
519 mad Javad Hosseini, Naina Raisinghani, Yi Su, Ni Lao, Daniel Formoso, Marco Gelmi, Almog  
520 Gueta, Tapomay Dey, Elena Gribovskaya, Domagoj Čević, Sidharth Mudgal, Garrett Bingham,  
521 Jianling Wang, Anurag Kumar, Alex Cullum, Feng Han, Konstantinos Bousmalis, Diego Cedillo,  
522 Grace Chu, Vladimir Magay, Paul Michel, Ester Hlavnova, Daniele Calandriello, Setareh Ari-  
523 afar, Kaisheng Yao, Vikash Sehwal, Arpi Vezer, Agustin Dal Lago, Zhenkai Zhu, Paul Kishan  
524 Rubenstein, Allen Porter, Anirudh Baddepudi, Oriana Riva, Mihai Dorin Istin, Chih-Kuan Yeh,  
525 Zhi Li, Andrew Howard, Nilpa Jha, Jeremy Chen, Raoul de Liedekerke, Zafarali Ahmed, Mikel  
526 Rodriguez, Tanuj Bhatia, Bangju Wang, Ali Elqursh, David Klinghoffer, Peter Chen, Pushmeet  
527 Kohli, Te I, Weiyang Zhang, Zack Nado, Jilin Chen, Maxwell Chen, George Zhang, Aayush  
528 Singh, Adam Hillier, Federico Lebron, Yiqing Tao, Ting Liu, Gabriel Dulac-Arnold, Jingwei  
529 Zhang, Shashi Narayan, Buhuang Liu, Orhan Firat, Abhishek Bhowmick, Bingyuan Liu, Hao  
530 Zhang, Zizhao Zhang, Georges Rotival, Nathan Howard, Anu Sinha, Alexander Grushetsky, Ben-  
531 jamin Beyret, Keerthana Gopalakrishnan, James Zhao, Kyle He, Szabolcs Payrits, Zaid Nabulsi,  
532 Zhaoyi Zhang, Weijie Chen, Edward Lee, Nova Fallen, Sreenivas Gollapudi, Aurick Zhou, Filip  
533 Pavetić, Thomas Köppe, Shiyu Huang, Rama Pasumarthi, Nick Fernando, Felix Fischer, Daria  
534 Čurko, Yang Gao, James Svensson, Austin Stone, Haroon Qureshi, Abhishek Sinha, Apoorv  
535 Kulshreshtha, Martin Matysiak, Jieming Mao, Carl Saroufim, Aleksandra Faust, Qingnan Duan,  
536 Gil Fidel, Kaan Katircioglu, Raphaël Lopez Kaufman, Dhruv Shah, Weize Kong, Abhishek  
537 Bapna, Gellért Weisz, Emma Dunleavy, Praneet Dutta, Tianqi Liu, Rahma Chaabouni, Carolina  
538 Parada, Marcus Wu, Alexandra Belias, Alessandro Bissacco, Stanislav Fort, Li Xiao, Fantine  
539 Huot, Chris Knutsen, Yochai Blau, Gang Li, Jennifer Prendki, Juliette Love, Yinlam Chow, Pichi  
Charoenpanit, Hidetoshi Shimokawa, Vincent Coriou, Karol Gregor, Tomas Izo, Arjun Akula,  
Mario Pinto, Chris Hahn, Dominik Paulus, Jiaxian Guo, Neha Sharma, Cho-Jui Hsieh, Adaye  
Chukwuka, Kazuma Hashimoto, Nathalie Rauschmayr, Ling Wu, Christof Angermueller, Yulong  
Wang, Sebastian Gerlach, Michael Pliskin, Daniil Mirylenka, Min Ma, Lexi Baugher, Bryan Gale,

540 Shaan Bijwadia, Nemanja Rakićević, David Wood, Jane Park, Chung-Ching Chang, Babi Seal,  
541 Chris Tar, Kacper Krasowiak, Yiwen Song, Georgi Stephanov, Gary Wang, Marcello Maggioni,  
542 Stein Xudong Lin, Felix Wu, Shachi Paul, Zixuan Jiang, Shubham Agrawal, Bilal Piot, Alex  
543 Feng, Cheolmin Kim, Tulsee Doshi, Jonathan Lai, Chuqiao, Xu, Sharad Vikram, Ciprian Chelba,  
544 Sebastian Krause, Vincent Zhuang, Jack Rae, Timo Denk, Adrian Collister, Lotte Weerts, Xi-  
545 anghong Luo, Yifeng Lu, Håvard Garnes, Nitish Gupta, Terry Spitz, Avinatan Hassidim, Lihao  
546 Liang, Izhak Shafran, Peter Humphreys, Kenny Vassigh, Phil Wallis, Virat Shejwalkar, Nicolas  
547 Perez-Nieves, Rachel Hornung, Melissa Tan, Beka Westberg, Andy Ly, Richard Zhang, Brian  
548 Farris, Jongbin Park, Alec Kosik, Zeynep Cankara, Andrii Maksai, Yunhan Xu, Albin Cassirer,  
549 Sergi Caelles, Abbas Abdolmaleki, Mencher Chiang, Alex Fabrikant, Shravya Shetty, Luheng  
550 He, Mai Giménez, Hadi Hashemi, Sheena Panthaplackel, Yana Kulizhskaya, Salil Deshmukh,  
551 Daniele Pighin, Robin Alazard, Disha Jindal, Seb Noury, Pradeep Kumar S, Siyang Qin, Xerxes  
552 Dotiwalla, Stephen Spencer, Mohammad Babaeizadeh, Blake JianHang Chen, Vaibhav Mehta,  
553 Jennie Lees, Andrew Leach, Penporn Koanantakool, Iliia Akolzin, Ramona Comanescu, Junwhan  
554 Ahn, Alexey Svyatkovskiy, Basil Mustafa, David D'Ambrosio, Shiva Mohan Reddy Garlapati,  
555 Pascal Lamblin, Alekh Agarwal, Shuang Song, Pier Giuseppe Sessa, Pauline Coquinot, John  
556 Maggs, Hussain Masoom, Divya Pitta, Yaqing Wang, Patrick Morris-Suzuki, Billy Porter, John-  
557 son Jia, Jeffrey Dudek, Raghavender R, Cosmin Paduraru, Alan Ansell, Tolga Bolukbasi, Tony  
558 Lu, Ramya Ganeshan, Zi Wang, Henry Griffiths, Rodrigo Benenson, Yifan He, James Swirhun,  
559 George Papamakarios, Aditya Chawla, Kuntal Sengupta, Yan Wang, Vedrana Milutinovic, Igor  
560 Mordatch, Zhipeng Jia, Jamie Smith, Will Ng, Shitij Nigam, Matt Young, Eugen Vušak, Blake  
561 Hechtman, Sheela Goenka, Avital Zipori, Kareem Ayoub, Ashok Papat, Trilok Acharya, Luo  
562 Yu, Dawn Bloxwich, Hugo Song, Paul Roit, Haiqiong Li, Aviel Boag, Nigamaa Nayakanti,  
563 Bilva Chandra, Tianli Ding, Aahil Mehta, Cath Hope, Jiageng Zhang, Idan Heimlich Shtacher,  
564 Kartikeya Badola, Ryo Nakashima, Andrei Sozanschi, Iulia Comşa, Ante Žužul, Emily Cave-  
565 ness, Julian Odell, Matthew Watson, Dario de Cesare, Phillip Lippe, Derek Lockhart, Siddharth  
566 Verma, Huizhong Chen, Sean Sun, Lin Zhuo, Aditya Shah, Prakhar Gupta, Alex Muzio, Ning  
567 Niu, Amir Zait, Abhinav Singh, Meenu Gaba, Fan Ye, Prajit Ramachandran, Mohammad Saleh,  
568 Raluca Ada Popa, Ayush Dubey, Frederick Liu, Sara Javanmardi, Mark Epstein, Ross Hemsley,  
569 Richard Green, Nishant Ranka, Eden Cohen, Chuyuan Kelly Fu, Sanjay Ghemawat, Jed Borovik,  
570 James Martens, Anthony Chen, Pranav Shyam, André Susano Pinto, Ming-Hsuan Frank, Alexan-  
571 dru Tifrea, David Du, Boqing Gong, Ayushi Agarwal, Seungyeon Kim, Christian Yang, Saloni  
572 Shah, Xiaodan Song, Zhiwei Deng, Ales Mikhalap, Kleopatra Chatziprimou, Timothy Chung,  
573 Toni Creswell, Susan Zhang, Yennie Jun, Carl Lebsack, Will Truong, Slavica Andačić, Itay Yona,  
574 Marco Fornoni, Rong Rong, Serge Toropov, Afzal Shama Soudagar, Andrew Audibert, Salah  
575 Zaiem, Zaheer Abbas, Andrei Rusu, Sahitya Potluri, Shitao Weng, Anastasios Kementsietsidis,  
576 Anton Tsitsulin, Daiyi Peng, Natalie Ha, Sanil Jain, Tejasi Latkar, Simeon Ivanov, Cory McLean,  
577 Anirudh GP, Rajesh Venkataraman, Canoe Liu, Dilip Krishnan, Joel D'sa, Roey Yogeve, Paul  
578 Collins, Benjamin Lee, Lewis Ho, Carl Doersch, Gal Yona, Shawn Gao, Felipe Tiengo Ferreira,  
579 Adnan Ozturel, Hannah Muckenhirn, Ce Zheng, Gargi Balasubramaniam, Mudit Bansal, George  
580 van den Driessche, Sivan Eiger, Salem Haykal, Vedant Misra, Abhimanyu Goyal, Danilo Martins,  
581 Gary Leung, Jonas Valfridsson, Four Flynn, Will Bishop, Chenxi Pang, Yoni Halpern, Honglin  
582 Yu, Lawrence Moore, Yuvein, Zhu, Sridhar Thiagarajan, Yoel Drori, Zhisheng Xiao, Lucio Dery,  
583 Rolf Jagerman, Jing Lu, Eric Ge, Vaibhav Aggarwal, Arjun Khare, Vinh Tran, Oded Elyada,  
584 Ferran Alet, James Rubin, Ian Chou, David Tian, Libin Bai, Lawrence Chan, Lukasz Lew, Karo-  
585 lis Misiunas, Taylan Bilal, Aniket Ray, Sindhu Raghuram, Alex Castro-Ros, Viral Carpenter,  
586 CJ Zheng, Michael Kilgore, Josef Broder, Emily Xue, Praveen Kallakuri, Dheeru Dua, Nancy  
587 Yuen, Steve Chien, John Schultz, Saurabh Agrawal, Reut Tsarfaty, Jingcao Hu, Ajay Kannan,  
588 Dror Marcus, Nisarg Kothari, Baochen Sun, Ben Horn, Matko Bošnjak, Ferjad Naem, Dean  
589 Hirsch, Lewis Chiang, Boya Fang, Jie Han, Qifei Wang, Ben Hora, Antoine He, Mario Lučić,  
590 Beer Changpinyo, Anshuman Tripathi, John Youssef, Chester Kwak, Philippe Schlattner, Cat  
591 Graves, Rémi Leblond, Wenjun Zeng, Anders Andreassen, Gabriel Rasskin, Yue Song, Eddie  
592 Cao, Junhyuk Oh, Matt Hoffman, Wojtek Skut, Yichi Zhang, Jon Stritar, Xingyu Cai, Saarthak  
593 Khanna, Kathie Wang, Shriya Sharma, Christian Reisswig, Younghoon Jun, Aman Prasad, Ta-  
tiana Sholokhova, Preeti Singh, Adi Gerzi Rosenthal, Anian Ruoss, Françoise Beaufays, Sean  
Kirmani, Dongkai Chen, Johan Schalkwyk, Jonathan Herzig, Been Kim, Josh Jacob, Damien  
Vincent, Adrian N Reyes, Ivana Balazevic, Léonard Hussenot, Jon Schneider, Parker Barnes,  
Luis Castro, Spandana Raj Babbula, Simon Green, Serkan Cabi, Nico Duduta, Danny Driess,  
Rich Galt, Noam Velan, Junjie Wang, Hongyang Jiao, Matthew Mauer, Du Phan, Miteyan Patel,

594 Vlado Galić, Jerry Chang, Eyal Marcus, Matt Harvey, Julian Salazar, Elahe Dabir, Suraj Satishku-  
595 mar Sheth, Amol Mandhane, Hanie Sedghi, Jeremiah Willcock, Amir Zandieh, Shruthi Prab-  
596 hakara, Aida Amini, Antoine Miech, Victor Stone, Massimo Nicosia, Paul Niemczyk, Ying Xiao,  
597 Lucy Kim, Sławek Kwasiborski, Vikas Verma, Ada Maksutaj Oflazer, Christoph Hirsenschall, Pe-  
598 ter Sung, Lu Liu, Richard Everett, Michiel Bakker, Ágoston Weisz, Yufei Wang, Vivek Sam-  
599 pathkumar, Uri Shaham, Bibo Xu, Yasemin Altun, Mingqiu Wang, Takaaki Saeki, Guanjie Chen,  
600 Emanuel Taropa, Shanthal Vasanth, Sophia Austin, Lu Huang, Goran Petrovic, Qingyun Dou,  
601 Daniel Golovin, Grigory Rozhdestvenskiy, Allie Culp, Will Wu, Motoki Sano, Divya Jain, Julia  
602 Proskurnia, Sébastien Cevey, Alejandro Cruzado Ruiz, Piyush Patil, Mahdi Mirzazadeh, Eric Ni,  
603 Javier Snaider, Lijie Fan, Alexandre Fréchette, AJ Pierigiovanni, Shariq Iqbal, Kenton Lee, Clau-  
604 dio Fantacci, Jinwei Xing, Lisa Wang, Alex Irpan, David Raposo, Yi Luan, Zhuoyuan Chen, Har-  
605 ish Ganapathy, Kevin Hui, Jiazhong Nie, Isabelle Guyon, Heming Ge, Roopali Vij, Hui Zheng,  
606 Dayeong Lee, Alfonso Castaño, Khuslen Baatarsukh, Gabriel Ibagon, Alexandra Chronopoulou,  
607 Nicholas FitzGerald, Shashank Viswanadha, Safeen Huda, Rivka Moroshko, Georgi Stoyanov,  
608 Prateek Kolhar, Alain Vaucher, Ishaan Watts, Adhi Kuncoro, Henryk Michalewski, Satish Kam-  
609 bala, Bat-Orgil Batsaikhan, Alek Andreev, Irina Jurenka, Maigo Le, Qihang Chen, Wael Al Jishi,  
610 Sarah Chakera, Zhe Chen, Aditya Kini, Vikas Yadav, Aditya Siddhant, Iliia Labzovsky, Balaji  
611 Lakshminarayanan, Carrie Grimes Bostock, Pankil Botadra, Ankesh Anand, Colton Bishop, Sam  
612 Conway-Rahman, Mohit Agarwal, Yani Donchev, Achintya Singhal, Félix de Chaumont Quitry,  
613 Natalia Ponomareva, Nishant Agrawal, Bin Ni, Kalpesh Krishna, Masha Samsikova, John Karro,  
614 Yilun Du, Tamara von Glehn, Caden Lu, Christopher A. Choquette-Choo, Zhen Qin, Tingnan  
615 Zhang, Sicheng Li, Divya Tyam, Swaroop Mishra, Wing Lowe, Colin Ji, Weiyi Wang, Man-  
616 aal Faruqui, Ambrose Slone, Valentin Dalibard, Arunachalam Narayanaswamy, John Lambert,  
617 Pierre-Antoine Manzagol, Dan Karliner, Andrew Bolt, Ivan Lobov, Aditya Kusupati, Chang  
618 Ye, Xuan Yang, Heiga Zen, Nelson George, Mukul Bhutani, Olivier Lacombe, Robert Riachi,  
619 Gagan Bansal, Rachel Soh, Yue Gao, Yang Yu, Adams Yu, Emily Nottage, Tania Rojas-Esponda,  
620 James Noraky, Manish Gupta, Ragha Kotikalapudi, Jichuan Chang, Sanja Deur, Dan Graur, Alex  
621 Mossin, Erin Farnese, Ricardo Figueira, Alexandre Moufarek, Austin Huang, Patrik Zochbauer,  
622 Ben Ingram, Tongzhou Chen, Zelin Wu, Adrià Puigdomènech, Leland Rechis, Da Yu, Sri Gay-  
623 atri Sundara Padmanabhan, Rui Zhu, Chu ling Ko, Andrea Banino, Samira Daruki, Aarush Sel-  
624 van, Dhruva Bhaswar, Daniel Hernandez Diaz, Chen Su, Salvatore Scellato, Jennifer Brennan,  
625 Woohyun Han, Grace Chung, Priyanka Agrawal, Urvashi Khandelwal, Khe Chai Sim, Mor-  
626 gane Lustman, Sam Ritter, Kelvin Guu, Jiawei Xia, Prateek Jain, Emma Wang, Tyrone Hill,  
627 Mirko Rossini, Marija Kostelac, Tautvydas Misiunas, Amit Sabne, Kyuyeun Kim, Ahmet Is-  
628 cen, Congchao Wang, José Leal, Ashwin Sreevatsa, Utku Evci, Manfred Warmuth, Saket Joshi,  
629 Daniel Suo, James Lottes, Garrett Honke, Brendan Jou, Stefani Karp, Jieru Hu, Himanshu Sahni,  
630 Adrien Ali Taïga, William Kong, Samrat Ghosh, Ren Shen Wang, Jay Pavagadhi, Natalie Axels-  
631 son, Nikolai Grigorev, Patrick Siegler, Rebecca Lin, Guohui Wang, Emilio Parisotto, Sharath  
632 Maddineni, Krishan Subudhi, Eyal Ben-David, Elena Pochernina, Orgad Keller, Thi Avrahami,  
633 Zhe Yuan, Pulkit Mehta, Jialu Liu, Sherry Yang, Wendy Kan, Katherine Lee, Tom Funkhouser,  
634 Derek Cheng, Hongzhi Shi, Archit Sharma, Joe Kelley, Matan Eyal, Yury Malkov, Corentin Tal-  
635 lec, Yuval Bahat, Shen Yan, Xintian, Wu, David Lindner, Chengda Wu, Avi Caciularu, Xiyang  
636 Luo, Rodolphe Jenatton, Tim Zaman, Yingying Bi, Ilya Kornakov, Ganesh Mallya, Daisuke  
637 Ikeda, Itay Karo, Anima Singh, Colin Evans, Praneeth Netrapalli, Vincent Nallatamby, Isaac  
638 Tian, Yannis Assael, Vikas Raunak, Victor Carbune, Ioana Bica, Lior Madmoni, Dee Cattle,  
639 Snchit Grover, Krishna Somandepalli, Sid Lall, Amelio Vázquez-Reina, Riccardo Patana, Jiaqi  
640 Mu, Pranav Talluri, Maggie Tran, Rajeev Aggarwal, RJ Skerry-Ryan, Jun Xu, Mike Burrows,  
641 Xiaoyue Pan, Edouard Yvinec, Di Lu, Zhiying Zhang, Duc Dung Nguyen, Hairong Mu, Gabriel  
642 Barcik, Helen Ran, Lauren Beltrone, Krzysztof Choromanski, Dia Kharrat, Samuel Albanie, Sean  
643 Purser-haskell, David Bieber, Carrie Zhang, Jing Wang, Tom Hudson, Zhiyuan Zhang, Han Fu,  
644 Johannes Mauerer, Mohammad Hossein Bateni, AJ Maschinot, Bing Wang, Muye Zhu, Arjun  
645 Pillai, Tobias Weyand, Shuang Liu, Oscar Akerlund, Fred Bertsch, Vittal Premachandran, Ali-  
646 cia Jin, Vincent Roulet, Peter de Boursac, Shubham Mittal, Ndaba Ndebele, Georgi Karadzhov,  
647 Sahra Ghalebikesabi, Ricky Liang, Allen Wu, Yale Cong, Nimesh Ghelani, Sumeet Singh, Bah-  
648 ar Fatemi, Warren, Chen, Charles Kwong, Alexey Kolganov, Steve Li, Richard Song, Chenkai  
649 Kuang, Sobhan Miryoosefi, Dale Webster, James Wendt, Arkadiusz Socala, Guolong Su, Artur  
650 Mendonça, Abhinav Gupta, Xiaowei Li, Tomy Tsai, Qiong, Hu, Kai Kang, Angie Chen, Ser-  
651 tan Girgin, Yongqin Xian, Andrew Lee, Nolan Ramsden, Leslie Baker, Madeleine Clare Elish,  
652 Varvara Krayvanova, Rishabh Joshi, Jiri Simsa, Yao-Yuan Yang, Piotr Ambroszczyk, Dipankar

648 Ghosh, Arjun Kar, Yuan Shangguan, Yumeya Yamamori, Yaroslav Akulov, Andy Brock, Hao-  
649 tian Tang, Siddharth Vashishtha, Rich Munoz, Andreas Steiner, Kalyan Andra, Daniel Eppens,  
650 Qixuan Feng, Hayato Kobayashi, Sasha Goldshtein, Mona El Mahdy, Xin Wang, Jilei, Wang,  
651 Richard Killam, Tom Kwiatkowski, Kavya Kopparapu, Serena Zhan, Chao Jia, Alexei Bende-  
652 bury, Sheryl Luo, Adrià Recasens, Timothy Knight, Jing Chen, Mohak Patel, YaGuang Li, Ben  
653 Withbroe, Dean Weesner, Kush Bhatia, Jie Ren, Danielle Eisenbud, Ebrahim Songhori, Yanhua  
654 Sun, Travis Choma, Tasos Kementsietsidis, Lucas Manning, Brian Roark, Wael Farhan, Jie Feng,  
655 Susheel Tatineni, James Cobon-Kerr, Yunjie Li, Lisa Anne Hendricks, Isaac Noble, Chris Breaux,  
656 Nate Kushman, Liqian Peng, Fuzhao Xue, Taylor Tobin, Jamie Rogers, Josh Lipschultz, Chris  
657 Alberti, Alexey Vlaskin, Mostafa Dehghani, Roshan Sharma, Tris Warkentin, Chen-Yu Lee, Be-  
658 nigno Urias, Da-Cheng Juan, Angad Chandorkar, Hila Sheftel, Ruibo Liu, Elnaz Davoodi, Borja  
659 De Balle Pigem, Kedar Dhamdhere, David Ross, Jonathan Hoech, Mahdis Mahdieh, Li Liu, Qiu-  
660 jia Li, Liam McCafferty, Chenxi Liu, Markus Mircea, Yunting Song, Omkar Savant, Alaa Saade,  
661 Colin Cherry, Vincent Hellendoorn, Siddharth Goyal, Paul Pucciarelli, David Vilar Torres, Zo-  
662 har Yahav, Hyo Lee, Lars Lowe Sjoesund, Christo Kirov, Bo Chang, Deepanway Ghoshal, Lu Li,  
663 Gilles Baechler, Sébastien Pereira, Tara Sainath, Anudhyan Boral, Dominik Grewe, Afief Halumi,  
664 Nguyet Minh Phu, Tianxiao Shen, Marco Tulio Ribeiro, Dhriti Varma, Alex Kaskasoli, Vlad Fein-  
665 berg, Navneet Potti, Jarrod Kahn, Mateus Wisniewski, Shakir Mohamed, Arnar Mar Hrafnkel-  
666 son, Bobak Shahriari, Jean-Baptiste Lespiau, Lisa Patel, Legg Yeung, Tom Paine, Lantau Mei,  
667 Alex Ramirez, Rakesh Shivanna, Li Zhong, Josh Woodward, Guilherme Tubone, Samira Khan,  
668 Heng Chen, Elizabeth Nielsen, Catalin Ionescu, Utsav Prabhu, Mingcen Gao, Qingze Wang, Sean  
669 Augenstein, Neesha Subramaniam, Jason Chang, Fotis Iliopoulos, Jiaming Luo, Myriam Khan,  
670 Weicheng Kuo, Denis Teplyashin, Florence Perot, Logan Kilpatrick, Amir Globerson, Hongkun  
671 Yu, Anfal Siddiqui, Nick Sukhanov, Arun Kandoor, Umang Gupta, Marco Andreetto, Moran  
672 Ambar, Donnie Kim, Paweł Wesolowski, Sarah Perrin, Ben Limonchik, Wei Fan, Jim Stephan,  
673 Ian Stewart-Binks, Ryan Kappedal, Tong He, Sarah Cogan, Romina Datta, Tong Zhou, Jiayu  
674 Ye, Leandro Kieliger, Ana Ramalho, Kyle Kastner, Fabian Mentzer, Wei-Jen Ko, Arun Suggala,  
675 Tianhao Zhou, Shiraz Butt, Hana Strejček, Lior Belenki, Subhashini Venugopalan, Mingyang  
676 Ling, Evgenii Eltyshev, Yunxiao Deng, Geza Kovacs, Mukund Raghavachari, Hanjun Dai, Tal  
677 Schuster, Steven Schwarcz, Richard Nguyen, Arthur Nguyen, Gavin Buttimore, Shrestha Basu  
678 Mallick, Sudeep Gandhe, Seth Benjamin, Michal Jastrzebski, Le Yan, Sugato Basu, Chris Apps,  
679 Isabel Edkins, James Allingham, Immanuel Odisho, Tomas Kocisky, Jewel Zhao, Linting Xue,  
680 Apoorv Reddy, Chrysovalantis Anastasiou, Aviel Atias, Sam Redmond, Kieran Milan, Nico-  
681 las Heess, Herman Schmit, Allan Dafoe, Daniel Andor, Tynan Gangwani, Anca Dragan, Sheng  
682 Zhang, Ashyana Kachra, Gang Wu, Siyang Xue, Kevin Aydin, Siqi Liu, Yuxiang Zhou, Mahan  
683 Malihi, Austin Wu, Siddharth Gopal, Candice Schumann, Peter Stys, Alek Wang, Mirek Oľšák,  
684 Dangyi Liu, Christian Schallhart, Yiran Mao, Demetra Brady, Hao Xu, Tomas Mery, Chawin  
685 Sitawarin, Siva Velusamy, Tom Cobley, Alex Zhai, Christian Walder, Nitzan Katz, Ganesh Jawa-  
686 har, Chinmay Kulkarni, Antoine Yang, Adam Paszke, Yinan Wang, Bogdan Damoc, Zalán Bor-  
687 sos, Ray Smith, Jinning Li, Mansi Gupta, Andrei Kapishnikov, Sushant Prakash, Florian Luisier,  
688 Rishabh Agarwal, Will Grathwohl, Kuangyuan Chen, Kehang Han, Nikhil Mehta, Andrew Over,  
689 Shekoofeh Azizi, Lei Meng, Niccolò Dal Santo, Kelvin Zheng, Jane Shapiro, Igor Petrovski,  
690 Jeffrey Hui, Amin Ghafouri, Jasper Snoek, James Qin, Mandy Jordan, Caitlin Sikora, Jonathan  
691 Malmaud, Yuheng Kuang, Aga Świetlik, Ruoxin Sang, Chongyang Shi, Leon Li, Andrew Rosen-  
692 berg, Shubin Zhao, Andy Crawford, Jan-Thorsten Peter, Yun Lei, Xavier Garcia, Long Le, Todd  
693 Wang, Julien Amelot, Dave Orr, Praneeth Kacham, Dana Alon, Gladys Tyen, Abhinav Arora,  
694 James Lyon, Alex Kurakin, Mimi Ly, Theo Guidroz, Zhipeng Yan, Rina Panigrahy, Pingmei  
695 Xu, Thais Kagohara, Yong Cheng, Eric Noland, Jinhyuk Lee, Jonathan Lee, Cathy Yip, Maria  
696 Wang, Efrat Nehoran, Alexander Bykovsky, Zhihao Shan, Ankit Bhagatwala, Chaochao Yan, Jie  
697 Tan, Guillermo Garrido, Dan Ethier, Nate Hurley, Grace Vesom, Xu Chen, Siyuan Qiao, Ab-  
698 hishek Nayyar, Julian Walker, Paramjit Sandhu, Mihaela Rosca, Danny Swisher, Mikhail Dek-  
699 tiarev, Josh Dillon, George-Cristian Muraru, Manuel Tragut, Artiom Myaskovsky, David Reid,  
700 Marko Velic, Owen Xiao, Jasmine George, Mark Brand, Jing Li, Wenhao Yu, Shane Gu, Xiang  
701 Deng, François-Xavier Aubet, Soheil Hassas Yeganeh, Fred Alcober, Celine Smith, Trevor Cohn,  
Kay McKinney, Michael Tschannen, Ramesh Sampath, Gowoon Cheon, Liangchen Luo, Luyang  
Liu, Jordi Orbay, Hui Peng, Gabriela Botea, Xiaofan Zhang, Charles Yoon, Cesar Magalhaes,  
Paweł Stradomski, Ian Mackinnon, Steven Hemingray, Kumaran Venkatesan, Rhys May, Jaeyoun  
Kim, Alex Druinsky, Jingchen Ye, Zheng Xu, Terry Huang, Jad Al Abdallah, Adil Dostmohamed,  
Rachana Fellingner, Tsendsuren Munkhdalai, Akanksha Maurya, Peter Garst, Yin Zhang, Maxim

702 Krikun, Simon Bucher, Aditya Srikanth Veerubhotla, Yaxin Liu, Sheng Li, Nishesh Gupta, Jakub  
703 Adamek, Hanwen Chen, Bennett Orlando, Aleksandr Zaks, Joost van Amersfoort, Josh Camp, Hui  
704 Wan, HyunJeong Choe, Zhichun Wu, Kate Olszewska, Weiren Yu, Archita Vadali, Martin Scholz,  
705 Daniel De Freitas, Jason Lin, Amy Hua, Xin Liu, Frank Ding, Yichao Zhou, Boone Severson, Ka-  
706 terina Tsihlas, Samuel Yang, Tammo Spalink, Varun Yerram, Helena Pankov, Rory Blevins, Ben  
707 Vargas, Sarthak Jauhari, Matt Miecznikowski, Ming Zhang, Sandeep Kumar, Clement Farabet,  
708 Charline Le Lan, Sebastian Flennerhag, Yonatan Bitton, Ada Ma, Arthur Bražinskas, Eli Collins,  
709 Niharika Ahuja, Sneha Kudugunta, Anna Bortsova, Minh Giang, Wanzheng Zhu, Ed Chi, Scott  
710 Lundberg, Alexey Stern, Subha Puttagunta, Jing Xiong, Xiao Wu, Yash Pande, Amit Jhindal,  
711 Daniel Murphy, Jon Clark, Marc Brockschmidt, Maxine Deines, Kevin R. McKee, Dan Bahir,  
712 Jiajun Shen, Minh Truong, Daniel McDuff, Andrea Gesmundo, Edouard Rosseel, Bowen Liang,  
713 Ken Caluwaerts, Jessica Hamrick, Joseph Kready, Mary Cassin, Rishikesh Ingale, Li Lao, Scott  
714 Pollom, Yifan Ding, Wei He, Lizzeth Bellot, Joana Ijazi, Ramya Sree Boppana, Shan Han, Tara  
715 Thompson, Amr Khalifa, Anna Bulanova, Blagoj Mitrevski, Bo Pang, Emma Cooney, Tian Shi,  
716 Rey Coaguila, Tamar Yakar, Marc’auelio Ranzato, Nikola Momchev, Chris Rawles, Zachary  
717 Charles, Young Maeng, Yuan Zhang, Rishabh Bansal, Xiaokai Zhao, Brian Albert, Yuan Yuan,  
718 Sudheendra Vijayanarasimhan, Roy Hirsch, Vinay Ramasesh, Kiran Vodrahalli, Xingyu Wang,  
719 Arushi Gupta, DJ Strouse, Jianmo Ni, Roma Patel, Gabe Taubman, Zhouyuan Huo, Dero Gharib-  
720 ian, Marianne Monteiro, Hoi Lam, Shobha Vasudevan, Aditi Chaudhary, Isabela Albuquerque,  
721 Kilol Gupta, Sebastian Riedel, Chaitra Hegde, Avraham Ruderman, András György, Marcus  
722 Wainwright, Ashwin Chaugule, Burcu Karagol Ayan, Tomer Levinboim, Sam Shleifer, Yogesh  
723 Kalley, Vahab Mirrokni, Abhishek Rao, Prabakar Radhakrishnan, Jay Hartford, Jialin Wu, Zhen-  
724 hai Zhu, Francesco Bertolini, Hao Xiong, Nicolas Serrano, Hamish Tomlinson, Myle Ott, Yifan  
725 Chang, Mark Graham, Jian Li, Marco Liang, Xiangzhu Long, Sebastian Borgeaud, Yanif Ahmad,  
726 Alex Grills, Diana Mincu, Martin Izzard, Yuan Liu, Jinyu Xie, Louis O’Byrne, Sameera Ponda,  
727 Simon Tong, Michelle Liu, Dan Malkin, Khalid Salama, Yuankai Chen, Rohan Anil, Anand Rao,  
728 Rigel Swavely, Misha Bilenko, Nina Anderson, Tat Tan, Jing Xie, Xing Wu, Lijun Yu, Oriol  
729 Vinyals, Andrey Ryabtsev, Rumens Dangovski, Kate Baumli, Daniel Keysers, Christian Wright,  
730 Zoe Ashwood, Betty Chan, Artem Shtefan, Yaohui Guo, Ankur Bapna, Radu Soricut, Steven  
731 Pecht, Sabela Ramos, Rui Wang, Jiahao Cai, Trieu Trinh, Paul Barham, Linda Friso, Eli Stickgold,  
732 Xiangzhuo Ding, Siamak Shakeri, Diego Ardila, Eleftheria Briakou, Phil Culliton, Adam Raveret,  
733 Jingyu Cui, David Saxton, Subhrajit Roy, Javad Azizi, Pengcheng Yin, Lucia Loher, Andrew Bun-  
734 ner, Min Choi, Faruk Ahmed, Eric Li, Yin Li, Shengyang Dai, Michael Elabd, Sriram Ganapathy,  
735 Shivani Agrawal, Yiqing Hua, Paige Kunkle, Sujevan Rajayogam, Arun Ahuja, Arthur Conmy,  
736 Alex Vasiloff, Parker Beak, Christopher Yew, Jayaram Mudigonda, Bartek Wydrowski, Jon Blan-  
737 ton, Zhengdong Wang, Yann Dauphin, Zhuo Xu, Martin Polacek, Xi Chen, Hexiang Hu, Pauline  
738 Sho, Markus Kunesch, Mehdi Hafezi Manshadi, Eliza Rutherford, Bo Li, Sissie Hsiao, Iain Barr,  
739 Alex Tudor, Matija Kecman, Arsha Nagrani, Vladimir Pchelin, Martin Sundermeyer, Aishwarya P  
740 S, Abhijit Karmarkar, Yi Gao, Grishma Chole, Olivier Bachem, Isabel Gao, Arturo BC, Matt  
741 Dibb, Mauro Verzetti, Felix Hernandez-Campos, Yana Lunts, Matthew Johnson, Julia Di Trapani,  
742 Raphael Koster, Idan Brusilovsky, Binbin Xiong, Megha Mohabey, Han Ke, Joe Zou, Tea Sabolić,  
743 Víctor Campos, John Palowitch, Alex Morris, Linhai Qiu, Pranavaraj Ponnuramu, Fangtao Li,  
744 Vivek Sharma, Kiranbir Sodhia, Kaan Tekelioglu, Aleksandr Chuklin, Madhavi Yenugula, Erika  
745 Gemzer, Theofilos Strinopoulos, Sam El-Husseini, Huiyu Wang, Yan Zhong, Edouard Leurent,  
746 Paul Natsev, Weijun Wang, Dre Mahaarachchi, Tao Zhu, Songyou Peng, Sami Alabed, Cheng-  
747 Chun Lee, Anthony Brohan, Arthur Szlam, GS Oh, Anton Kovsharov, Jenny Lee, Renee Wong,  
748 Megan Barnes, Gregory Thornton, Felix Gimeno, Omer Levy, Martin Sevenich, Melvin Johnson,  
749 Jonathan Mallinson, Robert Dadashi, Ziyue Wang, Qingchun Ren, Preethi Lahoti, Arka Dhar,  
750 Josh Feldman, Dan Zheng, Thatcher Ulrich, Liviu Panait, Michiel Blokzijl, Cip Baetu, Josip  
751 Matak, Jitendra Harlalka, Maulik Shah, Tal Marian, Daniel von Dincklage, Cosmo Du, Ruy Ley-  
752 Wild, Bethanie Brownfield, Max Schumacher, Yury Stuken, Shadi Noghabi, Sonal Gupta, Xiaoqi  
753 Ren, Eric Malmi, Felix Weissenberger, Blanca Huergo, Maria Bauza, Thomas Lampe, Arthur  
754 Douillard, Mojtaba Seyedhosseini, Roy Frostig, Zoubin Ghahramani, Kelvin Nguyen, Kashyap  
755 Krishnakumar, Chengxi Ye, Rahul Gupta, Alireza Nazari, Robert Geirhos, Pete Shaw, Ahmed  
Eleryan, Dima Damen, Jennimaria Palomaki, Ted Xiao, Qiyin Wu, Quan Yuan, Phoenix Mead-  
owlark, Matthew Bilotti, Raymond Lin, Mukund Sridhar, Yannick Schroecker, Da-Woon Chung,  
Jincheng Luo, Trevor Strohman, Tianlin Liu, Anne Zheng, Jesse Emond, Wei Wang, Andrew  
Lampinen, Toshiyuki Fukuzawa, Folawiyo Campbell-Ajala, Monica Roy, James Lee-Thorp, Lily  
Wang, Iftekhar Naim, Tony, Nguy ên, Guy Bensusky, Aditya Gupta, Dominika Rogozińska, Justin

756 Fu, Thanumalayan Sankaranarayana Pillai, Petar Veličković, Shahar Drath, Philipp Neubeck,  
757 Vaibhav Tulsyan, Arseniy Klimovskiy, Don Metzler, Sage Stevens, Angel Yeh, Junwei Yuan,  
758 Tianhe Yu, Kelvin Zhang, Alec Go, Vincent Tsang, Ying Xu, Andy Wan, Isaac Galatzer-Levy,  
759 Sam Sobell, Abodunrinwa Toki, Elizabeth Salesky, Wenlei Zhou, Diego Antognini, Sholto Dou-  
760 glas, Shimu Wu, Adam Lelkes, Frank Kim, Paul Cavallaro, Ana Salazar, Yuchi Liu, James Besley,  
761 Tiziana Refice, Yiling Jia, Zhang Li, Michal Sokolik, Arvind Kannan, Jon Simon, Jo Chick, Avia  
762 Aharon, Meet Gandhi, Mayank Daswani, Keyvan Amiri, Vighnesh Birodkar, Abe Ittycheriah,  
763 Peter Grabowski, Oscar Chang, Charles Sutton, Zhixin, Lai, Umesh Telang, Susie Sargsyan, Tao  
764 Jiang, Raphael Hoffmann, Nicole Brichtova, Matteo Hessel, Jonathan Halcrow, Sammy Jerome,  
765 Geoff Brown, Alex Tomala, Elena Buchatskaya, Dian Yu, Sachit Menon, Pol Moreno, Yuguo  
766 Liao, Vicky Zayats, Luming Tang, SQ Mah, Ashish Shenoy, Alex Siegman, Majid Hadian, Okwan  
767 Kwon, Tao Tu, Nima Khajehnouri, Ryan Foley, Parisa Haghani, Zhongru Wu, Vaishakh Keshava,  
768 Khyatti Gupta, Tony Bruguier, Rui Yao, Danny Karmon, Luisa Zintgraf, Zhicheng Wang, En-  
769 rique Piqueras, Junehyuk Jung, Jenny Brennan, Diego Machado, Marissa Giustina, MH Tessler,  
770 Kamyu Lee, Qiao Zhang, Joss Moore, Kaspar Daugaard, Alexander Frömmgen, Jennifer Beat-  
771 tie, Fred Zhang, Daniel Kasenberg, Ty Geri, Danfeng Qin, Gaurav Singh Tomar, Tom Ouyang,  
772 Tianli Yu, Luwei Zhou, Rajiv Mathews, Andy Davis, Yaoyiran Li, Jai Gupta, Damion Yates,  
773 Linda Deng, Elizabeth Kemp, Ga-Young Joung, Sergei Vassilvitskii, Mandy Guo, Pallavi LV,  
774 Dave Dopson, Sami Lachgar, Lara McConnaughey, Himadri Choudhury, Dragos Dena, Aaron  
775 Cohen, Joshua Ainslie, Sergey Levi, Parthasarathy Gopavarapu, Polina Zablotskaia, Hugo Val-  
776 let, Sanaz Bahargam, Xiaodan Tang, Nenad Tomasev, Ethan Dyer, Daniel Balle, Hongrae Lee,  
777 William Bono, Jorge Gonzalez Mendez, Vadim Zubov, Shentao Yang, Ivor Rendulic, Yanyan  
778 Zheng, Andrew Hogue, Golan Pundak, Ralph Leith, Avishkar Bhoopchand, Michael Han, Mis-  
779 lav Žanić, Tom Schaul, Manolis Delakis, Tejas Iyer, Guanyu Wang, Harman Singh, Abdelrah-  
780 man Abdelhamed, Tara Thomas, Siddhartha Brahma, Hilal Dib, Naveen Kumar, Wenxuan Zhou,  
781 Liang Bai, Pushkar Mishra, Jiao Sun, Valentin Anklin, Roykrong Sukkerd, Lauren Agubuzu, An-  
782 ton Briukhov, Anmol Gulati, Maximilian Sieb, Fabio Pardo, Sara Nasso, Junquan Chen, Kexin  
783 Zhu, Tiberiu Sosea, Alex Goldin, Keith Rush, Spurthi Amba Hombaiah, Andreas Noever, Al-  
784 lan Zhou, Sam Haves, Mary Phuong, Jake Ades, Yi ting Chen, Lin Yang, Joseph Pagadora,  
785 Stan Bileschi, Victor Cotruta, Rachel Saputro, Arijit Pramanik, Sean Ammirati, Dan Garrette,  
786 Kevin Villela, Tim Blyth, Canfer Akbulut, Neha Jha, Alban Rustemi, Arissa Wongpanich, Chi-  
787 rag Nagpal, Yonghui Wu, Morgane Rivière, Sergey Kishchenko, Pranesh Srinivasan, Alice Chen,  
788 Animesh Sinha, Trang Pham, Bill Jia, Tom Hennigan, Anton Bakalov, Nithya Attaluri, Drew  
789 Garmon, Daniel Rodriguez, Dawid Wegner, Wenhao Jia, Evan Senter, Noah Fiedel, Denis Pe-  
790 tek, Yuchuan Liu, Cassidy Hardin, Harshal Tushar Lehri, Joao Carreira, Sara Smoot, Marcel  
791 Prasetya, Nami Akazawa, Anca Stefanoiu, Chia-Hua Ho, Anelia Angelova, Kate Lin, Min Kim,  
792 Charles Chen, Marcin Sieniek, Alice Li, Tongfei Guo, Sorin Baltateanu, Pouya Tafti, Michael  
793 Wunder, Nadav Olmert, Divyansh Shukla, Jingwei Shen, Neel Kovelamudi, Balaji Venkatraman,  
794 Seth Neel, Romal Thoppilan, Jerome Connor, Frederik Benzing, Axel Stjerngren, Goltaz Ghi-  
795 asi, Alex Polozov, Joshua Howland, Theophane Weber, Justin Chiu, Ganesh Poomal Girirajan,  
796 Andreas Terzis, Pidong Wang, Fangda Li, Yoav Ben Shalom, Dinesh Tewari, Matthew Denton,  
797 Roe Aharoni, Norbert Kalb, Heri Zhao, Junlin Zhang, Angelos Filos, Matthew Rahtz, Lalit Jain,  
798 Connie Fan, Vitor Rodrigues, Ruth Wang, Richard Shin, Jacob Austin, Roman Ring, Mariella  
799 Sanchez-Vargas, Mehadi Hassen, Ido Kessler, Uri Alon, Gufeng Zhang, Wenhao Chen, Yenai Ma,  
800 Xiance Si, Le Hou, Azalia Mirhoseini, Marc Wilson, Geoff Bacon, Becca Roelofs, Lei Shu,  
801 Gautam Vasudevan, Jonas Adler, Artur Dwornik, Tayfun Terzi, Matt Lawlor, Harry Askham,  
802 Mike Bernico, Xuanyi Dong, Chris Hidey, Kevin Kilgour, Gaël Liu, Surya Bhupatiraju, Luke  
803 Leonhard, Siqi Zuo, Partha Talukdar, Qing Wei, Aliaksei Severyn, Vít Lišík, Jong Lee, Aditya  
804 Tripathi, SK Park, Yossi Matias, Hao Liu, Alex Ruiz, Rajesh Jayaram, Jackson Tolins, Pierre  
805 Marcenac, Yiming Wang, Bryan Seybold, Henry Prior, Deepak Sharma, Jack Weber, Mikhail  
806 Sirotenko, Yunhsuan Sung, Dayou Du, Ellie Pavlick, Stefan Zinke, Markus Freitag, Max Dylla,  
807 Montse Gonzalez Arenas, Natan Potikha, Omer Goldman, Connie Tao, Rachita Chhaparia, Maria  
808 Voitovich, Pawan Dogra, Andrija Ražnatović, Zak Tsai, Chong You, Oleaser Johnson, George  
809 Tucker, Chenjie Gu, Jae Yoo, Maryam Majzoubi, Valentin Gabeur, Bahram Raad, Rocky Rhodes,  
Kashyap Kolipaka, Heidi Howard, Geta Sampemane, Benny Li, Chulayuth Asawaroengchai, Duy  
Nguyen, Chiyuan Zhang, Timothee Cour, Xinxin Yu, Zhao Fu, Joe Jiang, Po-Sen Huang, Gabriela  
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Swaroop Ramaswamy, Sayna Ebrahimi, Qiuchen Guo, Jeremy Shar, Gabe Barth-Maron, Sravanti  
Addepalli, Bryan Richter, Chin-Yi Cheng, Eugénie Rives, Fei Zheng, Johannes Griesser, Nishanth

810 Dikkala, Yoel Zeldes, Ilkin Safarli, Dipanjan Das, Himanshu Srivastava, Sadh MNM Khan, Xin  
811 Li, Aditya Pandey, Larisa Markeeva, Dan Belov, Qiqi Yan, Mikołaj Rybiński, Tao Chen, Megha  
812 Nawhal, Michael Quinn, Vineetha Govindaraj, Sarah York, Reed Roberts, Roopal Garg, Namrata  
813 Godbole, Jake Abernethy, Anil Das, Lam Nguyen Thiet, Jonathan Tompson, John Nham, Neera  
814 Vats, Ben Caine, Wesley Helmholtz, Francesco Pongetti, Yeongil Ko, James An, Clara Huiyi Hu,  
815 Yu-Cheng Ling, Julia Pawar, Robert Leland, Keisuke Kinoshita, Waleed Khawaja, Marco Selvi,  
816 Eugene Ie, Danila Sinopalnikov, Lev Proleev, Nilesh Tripuraneni, Michele Bevilacqua, Seungji  
817 Lee, Clayton Sanford, Dan Suh, Dustin Tran, Jeff Dean, Simon Baumgartner, Jens Heitkaemper,  
818 Sagar Gubbi, Kristina Toutanova, Yichong Xu, Chandu Thekkath, Keran Rong, Palak Jain, Annie  
819 Xie, Yan Virin, Yang Li, Lubo Litchev, Richard Powell, Tarun Bharti, Adam Kraft, Nan Hua,  
820 Marissa Ikonomidis, Ayal Hitron, Sanjiv Kumar, Loic Matthey, Sophie Bridgers, Lauren Lax,  
821 Ishaan Malhi, Ondrej Skopek, Ashish Gupta, Jiawei Cao, Michelle Rasquinha, Siim Pöder, Woj-  
822 ciech Stokowiec, Nicholas Roth, Guowang Li, Michaël Sander, Joshua Kessinger, Vihan Jain, Ed-  
823 ward Loper, Wonpyo Park, Michal Yarom, Liqun Cheng, Guru Guruganesh, Kanishka Rao, Yan  
824 Li, Catarina Barros, Mikhail Sushkov, Chun-Sung Ferng, Rohin Shah, Ophir Aharoni, Ravin Ku-  
825 mar, Tim McConnell, Peiran Li, Chen Wang, Fernando Pereira, Craig Swanson, Fayaz Jamil, Yan  
826 Xiong, Anitha Vijayakumar, Prakash Shroff, Kedar Soparkar, Jindong Gu, Livio Baldini Soares,  
827 Eric Wang, Kushal Majmundar, Aurora Wei, Kai Bailey, Nora Kassner, Chizu Kawamoto, Goran  
828 Žužić, Victor Gomes, Abhirut Gupta, Michael Guzman, Ishita Dasgupta, Xinyi Bai, Zhufeng Pan,  
829 Francesco Piccinno, Hadas Natalie Vogel, Octavio Ponce, Adrian Hutter, Paul Chang, Pan-Pan  
830 Jiang, Ionel Gog, Vlad Ionescu, James Manyika, Fabian Pedregosa, Harry Ragan, Zach Behrman,  
831 Ryan Mullins, Coline Devin, Aroonlok Pyne, Swapnil Gawde, Martin Chadwick, Yiming Gu,  
832 Sasan Tavakkol, Andy Twigg, Naman Goyal, Ndidi Elue, Anna Goldie, Srinivasan Venkatachary,  
833 Hongliang Fei, Ziqiang Feng, Marvin Ritter, Isabel Leal, Sudeep Dasari, Pei Sun, Alif Raditya  
834 Rochman, Brendan O’Donoghue, Yuchen Liu, Jim Sproch, Kai Chen, Natalie Clay, Slav Petrov,  
835 Sailesh Sidhwani, Ioana Mihailescu, Alex Panagopoulos, AJ Piergiovanni, Yunfei Bai, George  
836 Powell, Deep Karkhanis, Trevor Yacovone, Petr Mitrichev, Joe Kovac, Dave Uthus, Amir Yaz-  
837 danbakhsh, David Amos, Steven Zheng, Bing Zhang, Jin Miao, Bhuvana Ramabhadran, Soroush  
838 Radpour, Shantanu Thakoor, Josh Newlan, Oran Lang, Orion Jankowski, Shikhar Bharadwaj,  
839 Jean-Michel Sarr, Shereen Ashraf, Sneha Mondal, Jun Yan, Ankit Singh Rawat, Sarmishta Velury,  
840 Greg Kochanski, Tom Eccles, Franz Och, Abhanshu Sharma, Ethan Mahintorabi, Alex Gurney,  
841 Carrie Muir, Vered Cohen, Saksham Thakur, Adam Bloniarz, Asier Mujika, Alexander Pritzel,  
842 Paul Caron, Altaf Rahman, Fiona Lang, Yasumasa Onoe, Petar Sirkovic, Jay Hoover, Ying Jian,  
843 Pablo Duque, Arun Narayanan, David Soergel, Alex Haig, Loren Maggiore, Shyamal Buch,  
844 Josef Dean, Ilya Figotin, Igor Karpov, Shaleen Gupta, Denny Zhou, Muhuan Huang, Ashwin  
845 Vaswani, Christopher Sementur, Kaushik Shivakumar, Yu Watanabe, Vinodh Kumar Rajendran,  
846 Eva Lu, Yanhan Hou, Wenting Ye, Shikhar Vashishth, Nana Nti, Vytenis Sakenas, Darren Ni,  
847 Doug DeCarlo, Michael Bendersky, Sumit Bagri, Nacho Cano, Elijah Peake, Simon Tokumine,  
848 Varun Godbole, Carlos Guía, Tanya Lando, Vittorio Selo, Seher Ellis, Danny Tarlow, Daniel  
849 Gillick, Alessandro Epasto, Siddhartha Reddy Jonnalagadda, Meng Wei, Meiyang Xie, Ankur  
850 Taly, Michela Paganini, Mukund Sundararajan, Daniel Toyama, Ting Yu, Dessie Petrova, Aneesh  
851 Pappu, Rohan Agrawal, Senaka Buthpitiya, Justin Frye, Thomas Buschmann, Remi Crocker,  
852 Marco Tagliasacchi, Mengchao Wang, Da Huang, Sagi Perel, Brian Wieder, Hideto Kazawa,  
853 Weiyue Wang, Jeremy Cole, Himanshu Gupta, Ben Golan, Seojin Bang, Nitish Kulkarni, Ken  
854 Franko, Casper Liu, Doug Reid, Sid Dalmia, Jay Whang, Kevin Cen, Prasha Sundaram, Johan  
855 Ferret, Berivan Isik, Lucian Ionita, Guan Sun, Anna Shekhawat, Muqthar Mohammad, Philip  
856 Pham, Ronny Huang, Karthik Raman, Xingyi Zhou, Ross Mcilroy, Austin Myers, Sheng Peng,  
857 Jacob Scott, Paul Covington, Sofia Erell, Pratik Joshi, João Gabriel Oliveira, Natasha Noy, Tajwar  
858 Nasir, Jake Walker, Vera Axelrod, Tim Dozat, Pu Han, Chun-Te Chu, Eugene Weinstein, Anand  
859 Shukla, Shreyas Chandrakaladharan, Petra Poklucar, Bonnie Li, Ye Jin, Prem Eruvbetine, Steven  
860 Hansen, Avigail Dabush, Alon Jacovi, Samrat Phatale, Chen Zhu, Steven Baker, Mo Shomrat,  
861 Yang Xiao, Jean Pouget-Abadie, Mingyang Zhang, Fanny Wei, Yang Song, Helen King, Yiling  
862 Huang, Yun Zhu, Ruoxi Sun, Juliana Vicente Franco, Chu-Cheng Lin, Sho Arora, Hui, Li, Vi-  
863 vian Xia, Luke Vilnis, Mariano Schain, Kaiz Alarakyia, Laurel Prince, Aaron Phillips, Caleb  
Habtegebriel, Luyao Xu, Huan Gui, Santiago Ontanon, Lora Aroyo, Aaron Gill, Peggy Lu,  
Yash Katariya, Dhruv Madeka, Shankar Krishnan, Shubha Srinivas Raghvendra, James Freed-  
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tacharya, Victoria Langston, Yiming Li, Suyog Kotecha, Alex Yakubovich, Xinyun Chen, Pe-

864 tre Petrov, Tolly Powell, Yanzhang He, Corbin Quick, Kanav Garg, Dawsen Hwang, Yang Lu,  
865 Srinadh Bhojanapalli, Kristian Kjems, Ramin Mehran, Aaron Archer, Hado van Hasselt, Ash-  
866 win Balakrishna, JK Kearns, Meiqi Guo, Jason Riesa, Mikita Sazanovich, Xu Gao, Chris Sauer,  
867 Chengrun Yang, XiangHai Sheng, Thomas Jimma, Wouter Van Gansbeke, Vitaly Nikolaev, Wei  
868 Wei, Katie Millican, Ruizhe Zhao, Justin Snyder, Levent Bolelli, Maura O'Brien, Shawn Xu, Fei  
869 Xia, Wentao Yuan, Arvind Neelakantan, David Barker, Sachin Yadav, Hannah Kirkwood, Far-  
870 rooq Ahmad, Joel Wee, Jordan Grimstad, Boyu Wang, Matthew Wiethoff, Shane Settle, Miaosen  
871 Wang, Charles Blundell, Jingjing Chen, Chris Duvarney, Grace Hu, Olaf Ronneberger, Alex Lee,  
872 Yuanzhen Li, Abhishek Chakladar, Alena Butryna, Georgios Evangelopoulos, Guillaume Des-  
873 jardins, Jonni Kanerva, Henry Wang, Averi Nowak, Nick Li, Alyssa Loo, Art Khurshudov, Lau-  
874 rent El Shafey, Nagabhushan Baddi, Karel Lenc, Yasaman Razeghi, Tom Lieber, Amer Sinha,  
875 Xiao Ma, Yao Su, James Huang, Asahi Ushio, Hanna Klimczak-Plucińska, Kareem Mohamed,  
876 JD Chen, Simon Osindero, Stav Ginzburg, Lampros Lamprou, Vasilisa Bashlovkina, Duc-Hieu  
877 Tran, Ali Khodaei, Ankit Anand, Yixian Di, Ramy Eskander, Manish Reddy Vuyyuru, Jasmine  
878 Liu, Aishwarya Kamath, Roman Goldenberg, Mathias Bellaïche, Juliette Pluto, Bill Rosgen, Has-  
879 san Mansoor, William Wong, Suhas Ganesh, Eric Bailey, Scott Baird, Dan Deutsch, Jinoo Baek,  
880 Xuhui Jia, Chansoo Lee, Abe Friesen, Nathaniel Braun, Kate Lee, Amayika Panda, Steven M.  
881 Hernandez, Duncan Williams, Jianqiao Liu, Ethan Liang, Arnaud Autef, Emily Pitler, Deepali  
882 Jain, Phoebe Kirk, Oskar Bunyan, Jaume Sanchez Elias, Tongxin Yin, Machel Reid, Aedan  
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908 Behbahani, Alvaro Caceres, Michael Riley, Patrick Kane, Sandra Lefdal, Rob Willoughby, Paul  
909 Vicol, Lun Wang, Shujian Zhang, Ashleah Gill, Yu Liang, Gautam Prasad, Soroosh Mariooryad,  
910 Mehran Kazemi, Zifeng Wang, Kritika Muralidharan, Paul Voigtlaender, Jeffrey Zhao, Huanjie  
911 Zhou, Nina D'Souza, Aditi Mavalankar, Séb Arnold, Nick Young, Obaid Sarvana, Chace Lee,  
912 Milad Nasr, Tingting Zou, Seokhwan Kim, Lukas Haas, Kaushal Patel, Neslihan Bulut, David  
913 Parkinson, Courtney Biles, Dmitry Kalashnikov, Chi Ming To, Aviral Kumar, Jessica Austin, Alex  
914 Greve, Lei Zhang, Megha Goel, Yeqing Li, Sergey Yaroshenko, Max Chang, Abhishek Jindal, Ge-  
915 off Clark, Hagai Taitelbaum, Dale Johnson, Ofir Roval, Jeongwoo Ko, Anhad Mohananey, Chris-  
916 tian Schuler, Shenil Dodhia, Ruichao Li, Kazuki Osawa, Claire Cui, Peng Xu, Rushin Shah, Tao  
917 Huang, Ela Gruzewska, Nathan Clement, Mudit Verma, Olcan Sercinoglu, Hai Qian, Viral Shah,  
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Gunel, Jun Qian, Austin Tarango, Krzysztof Jastrzebski, Robert David, Jyn Shan, Parker Schuh,  
Kunal Lad, Willi Gierke, Mukundan Madhavan, Xinyi Chen, Mark Kurzeja, Rebeca Santamaria-  
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Vincent Perot, Nan Ding, Shlomi Cohen-Ganor, Victor Lavrenko, Junru Wu, Georgie Evans,

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919 Zeyu Zheng, Yizhong Liang, Evgeny Gladchenko, Reeve Ingle, Uri First, Pierre Sermanet, Char-  
920 lotte Magister, Mihajlo Velimirović, Sashank Reddi, Susanna Ricco, Eirikur Agustsson, Hartwig  
921 Adam, Nir Levine, David Gaddy, Dan Holtmann-Rice, Xuanhui Wang, Ashutosh Sathe, Abhi-  
922 jit Guha Roy, Blaž Bratanič, Alen Carin, Harsh Mehta, Silvano Bonacina, Nicola De Cao, Mara  
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## A PROMPT FOR QUESTION CLEANING

Listing 1: Prompt used for Question Cleaning

```

1080 Clean and standardize math questions by removing multiple-choice
1081 options, normalizing the answer format, identifying dependencies,
1082 and determining the language. For any answers expressed in
1083 MathML, convert them to LaTeX. Conversion of MathML in the
1084 **question** is *not required* (but preserve LaTeX if already
1085 present).
1086 Additionally, provide a clear **step-by-step reasoning**
1087 explaining how each part of the output was derived.
1088
1089 ### Instructions:
1090
1091 1. Identify and extract the core question text:
1092   * Remove all multiple-choice options (e.g., A-D or 1 4 ),
1093   ensuring the main question remains grammatically and
1094   semantically intact.
1095   * Preserve existing LaTeX in the question.
1096   * Do **not** convert MathML in the question. It may be
1097   retained as-is.
1098
1099 2. Normalize the answer:
1100   * If the answer is given as an option label (e.g., "Answer:
1101   B"), replace it with the corresponding value from the
1102   provided options.
1103   * If the answer is already a value, retain it.
1104   * If the answer is in MathML, convert it to LaTeX.
1105
1106 3. Determine dependency flags:
1107   * **Option-dependent:** Is the question understandable and
1108   solvable without access to the answer options? Mark `True` if
1109   the question lacks key information without them; otherwise,
1110   `False`.
1111   * **Diagram-dependent:** Does the question reference or rely
1112   on a diagram, figure, or visual element? Mark `True` or
1113   `False`.
1114
1115 4. Identify the language:
1116   * Detect and report the language of the question text (e.g.,
1117   `English`, `Hindi`, `Tamil`, etc.).
1118
1119 5. Provide reasoning:
1120   * For each output field (question, answer, flags, language),
1121   include a clear explanation of how the output was determined.
1122   * The reasoning should follow a logical step-by-step format,
1123   but does **not** need to be wrapped in any special ``
1124   block.
1125
1126 # Output Format
1127
1128 <question> cleaned question </question>
1129 <answer> cleaned answer </answer>
1130 <option_dependent> True/False </option_dependent>
1131 <diagram_dependent> True/False </diagram_dependent>
1132 <language> detected language </language>
1133
1134 * All math in the **answer** must be in LaTeX.

```

```

1134 * There should be no references to original option labels
1135 (e.g., "A", "1", or "Option B").
1136 * Ensure the cleaned question is coherent, self-contained, and
1137 grammatically correct.
1138 * The reasoning can be in free-text form and must explain how
1139 each part of the output was derived.
1140
1141 ### Example 1
1142 Input:
1143 What is the derivative of  $(x^2 + 3x + 5)$ ?
1144 A)  $(2x + 3)$ 
1145 B)  $(x + 3)$ 
1146 C)  $(x^2 + 3)$ 
1147 D)  $(2x + 5)$ 
1148 Answer: A
1149
1150 Output:
1151 <question> What is the derivative of  $(x^2 + 3x + 5)$ ? </question>
1152 <answer>  $(2x + 3)$  </answer>
1153 <option_dependent> False </option_dependent>
1154 <diagram_dependent> False </diagram_dependent>
1155 <language> English </language>
1156 \end{verbatim}
1157 \begin{verbatim}
1158 ### Example 2
1159 Input:
1160 <p>Simplify the following expression:</p>
1161 <math xmlns="http://www.w3.org/1998/Math/MathML">
1162   <mfrac>
1163     <msqrt>
1164       <msup><mi>a</mi><mn>2</mn></msup>
1165     </msqrt>
1166     <mi>a</mi>
1167   </mfrac>
1168 </math>
1169 <p>Options:</p>
1170 1) <math
1171   xmlns="http://www.w3.org/1998/Math/MathML"><msqrt><mi>a</mi>
1172 </msqrt></math>
1173 2) <math
1174   xmlns="http://www.w3.org/1998/Math/MathML"><mi>a</mi></math>
1175 3) <math
1176   xmlns="http://www.w3.org/1998/Math/MathML"><mfrac><mn>1</mn><mi>a
1177 </mi></mfrac></math>
1178 4) <math
1179   xmlns="http://www.w3.org/1998/Math/MathML"><mn>1</mn></math>
1180 Answer: 1
1181
1182 Output:
1183 <question> Simplify the following expression:
1184 <math xmlns="http://www.w3.org/1998/Math/MathML">
1185   <mfrac>
1186     <msqrt>
1187       <msup><mi>a</mi><mn>2</mn></msup>

```

```

1188     </mfrac>
1189 </math>
1190 </question>
1191 <answer> \sqrt{a} </answer>
1192 <option_dependent> False </option_dependent>
1193 <diagram_dependent> False </diagram_dependent>
1194 <language> English </language>

```

## B PROMPTS FOR ANSWER MATCHING

MCQ	Numerical
<p><b>System Prompt:</b></p> <p>You are checking an MCQ. Given the list of options, determine if answer 1 and answer 2 are the same. Answer 1 is the same as answer 2 only if all the options match. Reason step-by-step and put the final answer YES or NO in <code>\boxed{}</code>.</p>	<p><b>System Prompt:</b></p> <p>You are checking an exam. For a given question, determine if answer 1 and answer 2 are the same. Since the answers are for the same question, you can assume similar context for both answers and make appropriate assumptions when checking if they are the same. Reason step-by-step and put the final answer YES or NO in <code>\boxed{}</code>.</p>
<p><b>User Prompt:</b></p> <p>Options:  A: &lt;Option 1&gt;  B: &lt;Option 2&gt;  C: &lt;Option 3&gt;  D: &lt;Option 4&gt;  answer 1: &lt;Correct Answer&gt;  answer 2: &lt;Predicted Answer&gt;</p>	<p><b>User Prompt:</b></p> <p>answer 1: &lt;Correct Answer&gt;  answer 2: &lt;Predicted Answer&gt;</p>

Table 4: Prompts used for Answer Matching

## C HYPER-PARAMETERS FOR SUPERVISED FINE TUNING

The hyper-parameters for LoRA are provided in the Table 5 and the hyper-parameters for SFT are provided in the Table 6.

Table 5: PEFT configuration using LoRA.

Parameter	Value
Rank	128
LoRA Alpha	128
LoRA Dropout	0.1
Bias	none
Target Modules	{q_proj, k_proj, v_proj, o_proj, gate_proj, up_proj, down_proj, embeddings}

Table 6: Training configuration used for supervised fine-tuning.

Parameter	Value
Precision	bfloat16
Max Sequence Length	16,384
Batch Size (per device)	1
Gradient Accumulation Steps	16
Effective Batch Size	16
Number of Epochs	3
Initial Learning Rate	$2 \times 10^{-5}$
Final Learning Rate	$2 \times 10^{-7}$
Learning Rate Scheduler	Linear
Optimizer	AdamW (8-bit)
Warmup Steps	5
Packing	False
Logging Steps	1
WandB Reporting	Enabled

## D EXAMPLE MODEL RESPONSES

The sample question along with its correct answer is presented in Figure 2.

The response generated by GPT-4o is shown in Figure 3.

The response produced by DeepSeek R1 Distill Qwen 7B is illustrated across Figures 4, 5, and 6.

The response from Aryabhata 1.0 is depicted in Figure 7.

*Question :*

Let  $y = f(x)$  be the solution of the differential equation  $\frac{dy}{dx} + \frac{xy}{x^2-1} = \frac{x^4+4x}{\sqrt{1-x^2}}$ ,  $-1 < x < 1$  such that  $f(0) = 0$ . If  $6 \int_{-1/2}^{1/2} f(x)dx = 2\pi - \alpha$  then  $\alpha^2$  is equal to:

Answer:

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Figure 2: Sample question with the correct answer

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Given the differential equation and initial condition:

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$$\frac{dy}{dx} + \frac{xy}{x^2 - 1} = \frac{x^4 + 4x}{\sqrt{1 - x^2}}, \quad -1 < x < 1 \quad \text{with} \quad f(0) = 0,$$

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we solve the differential equation using the method of integrating factors. The integrating factor,  $\mu(x)$ , is given by:

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$$\mu(x) = e^{\int \frac{x}{x^2 - 1} dx}.$$

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To find this, we simplify the integral:

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$$\int \frac{x}{x^2 - 1} dx.$$

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We use partial fractions:

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$$\frac{x}{x^2 - 1} = \frac{x}{(x - 1)(x + 1)} = \frac{1/2}{x - 1} + \frac{1/2}{x + 1}.$$

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Thus,

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$$\int \frac{x}{x^2 - 1} dx = \int \frac{1/2}{x - 1} dx + \int \frac{1/2}{x + 1} dx = \frac{1}{2} \ln|x - 1| + \frac{1}{2} \ln|x + 1| = \frac{1}{2} \ln|(x - 1)(x + 1)|.$$

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So, the integrating factor is:

$$\mu(x) = e^{\frac{1}{2} \ln|(x - 1)(x + 1)|} = \sqrt{|(x - 1)(x + 1)|}.$$

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Since  $-1 < x < 1$ ,  $\sqrt{|(x - 1)(x + 1)|}$  simplifies to  $\sqrt{1 - x^2}$ .

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Multiplying the differential equation by the integrating factor:

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$$\sqrt{1 - x^2} \frac{dy}{dx} + \frac{x\sqrt{1 - x^2}y}{x^2 - 1} = x^4 + 4x.$$

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This rearranges to:

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$$\frac{d}{dx}(y\sqrt{1 - x^2}) = x^4 + 4x.$$

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Integrating both sides w.r.t.  $x$ :

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$$y\sqrt{1 - x^2} = \int (x^4 + 4x) dx.$$

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Let:

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$$\int x^4 dx = \frac{x^5}{5}, \quad \int 4x dx = 2x^2.$$

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Thus:

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$$y\sqrt{1 - x^2} = \frac{x^5}{5} + 2x^2 + C.$$

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Given  $f(0) = 0$ :

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$$0 = \frac{0^5}{5} + 2 \cdot 0^2 + C \implies C = 0.$$

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So:

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$$y\sqrt{1 - x^2} = \frac{x^5}{5} + 2x^2.$$

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And:

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$$y = \frac{x^5/5 + 2x^2}{\sqrt{1 - x^2}}.$$

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We want  $\int_{-1/2}^{1/2} f(x) dx = \int_{-1/2}^{1/2} \frac{x^5/5 + 2x^2}{\sqrt{1 - x^2}} dx$ .

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Solving using symmetry and standard integral forms: Thus:

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$$\int_{-1/2}^{1/2} f(x) dx = \frac{2\pi}{6} - \frac{\alpha}{6}.$$

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Hence, equating both expressions:

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$$6 \int_{-1/2}^{1/2} f(x) dx = 2\pi - \alpha.$$

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Thus:

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$$\alpha = \frac{\pi}{3},$$

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and:  $\alpha^2 = \left(\frac{\pi}{3}\right)^2 = \frac{\pi^2}{9}$ . So:  $\boxed{\frac{\pi^2}{9}}$ .

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Figure 3: Response from GPT-4o (Part 1 of 1)

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1353 <think> Okay, so I have this differential equation to solve:  $\frac{dy}{dx} + \frac{xy}{x^2-1} = \frac{x^4+4x}{\sqrt{1-x^2}}$ , with the condition that  $f(0) = 0$ . Then, after finding  
 1354  $f(x)$ , I need to compute  $6 \int_{-1/2}^{1/2} f(x) dx$ , which equals  $2\pi - \alpha$ . Finally, I have to find  $\alpha^2$ . Hmm, that seems a bit involved, but let's break  
 1355 it down step by step.

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First, the differential equation is linear. It's in the form  $\frac{dy}{dx} + P(x)y = Q(x)$ . So, I can use an integrating factor to solve it. The  
 1356 standard method for linear differential equations is to find an integrating factor  $\mu(x) = \exp(\int P(x) dx)$ . Then, multiply both sides of  
 the equation by  $\mu(x)$  and integrate.

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Let me write down the equation again:

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$$\frac{dy}{dx} + \left( \frac{x}{x^2-1} \right) y = \frac{x^4+4x}{\sqrt{1-x^2}}$$

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So,  $P(x) = \frac{x}{x^2-1}$ , and  $Q(x) = \frac{x^4+4x}{\sqrt{1-x^2}}$ .

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First, let's compute the integrating factor  $\mu(x)$ :

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$$\mu(x) = \exp\left(\int \frac{x}{x^2-1} dx\right)$$

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1364 Hmm, the integral of  $\frac{x}{x^2-1} dx$ . Let me make a substitution. Let  $u = x^2 - 1$ , then  $du/dx = 2x$ , so  $\frac{1}{2} du = x dx$ . Therefore, the integral  
 1365 becomes  $\frac{1}{2} \int \frac{du}{u} = \frac{1}{2} \ln |u| + C = \frac{1}{2} \ln |x^2 - 1| + C$ .

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So,

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$$\mu(x) = \exp\left(\frac{1}{2} \ln |x^2 - 1|\right) = |x^2 - 1|^{1/2}$$

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Since we're working in the interval  $-1 < x < 1$ ,  $x^2 - 1$  is negative, so  $|x^2 - 1| = 1 - x^2$ . Therefore,  $\mu(x) = \sqrt{1 - x^2}$ .

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Wait, that's interesting. So, the integrating factor is  $\sqrt{1 - x^2}$ . Let me write that down:

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$$\mu(x) = \sqrt{1 - x^2}$$

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Now, multiply both sides of the differential equation by  $\mu(x)$ :

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$$\sqrt{1-x^2} \frac{dy}{dx} + \sqrt{1-x^2} \cdot \left( \frac{x}{x^2-1} \right) y = \frac{(x^4+4x)}{\sqrt{1-x^2}} \cdot \sqrt{1-x^2}$$

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Simplify each term:

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First term:  $\sqrt{1-x^2} \frac{dy}{dx}$

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Second term:  $\sqrt{1-x^2} \cdot \left( \frac{x}{x^2-1} \right) y = \frac{x}{\sqrt{1-x^2}(x^2-1)} y$

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Wait,  $x^2 - 1$  is negative, so  $x^2 - 1 = -(1 - x^2)$ . Therefore,

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$$\frac{x}{\sqrt{1-x^2}(x^2-1)} = \frac{-x}{(1-x^2)^{3/2}}$$

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Wait, maybe I should think differently. Let me compute the left-hand side after multiplying by  $\mu(x)$ . The left-hand side should be  
 1380 the derivative of  $\mu(x)y$ . Let me check:

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$$\frac{d}{dx}[\mu(x)y] = \mu'(x)y + \mu(x) \frac{dy}{dx}$$

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So, let's compute  $\mu'(x)$ :

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$$\mu(x) = (1-x^2)^{1/2}, \quad \mu'(x) = \frac{1}{2}(1-x^2)^{-1/2}(-2x) = \frac{-x}{\sqrt{1-x^2}}$$

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Therefore,

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$$\frac{d}{dx}[\mu(x)y] = \frac{-x}{\sqrt{1-x^2}} y + \sqrt{1-x^2} \frac{dy}{dx}$$

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Which is exactly the left-hand side of the equation after multiplying by  $\mu(x)$ . So, that's correct.

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Therefore, the equation becomes:

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$$\frac{d}{dx}[\sqrt{1-x^2}y] = x^4 + 4x$$

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Now, to solve for  $y$ , we can integrate both sides with respect to  $x$ :

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$$\sqrt{1-x^2}y = \int (x^4 + 4x) dx + C$$

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Compute the integral on the right:

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$$\int (x^4 + 4x) dx = \int x^4 dx + \int 4x dx = \frac{x^5}{5} + 2x^2 + C$$

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So,

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$$\sqrt{1-x^2}y = \frac{x^5}{5} + 2x^2 + C$$

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Figure 4: Response from DeepSeek R1 Distill Qwen 7B (Part 1 of 3)

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Therefore, solving for  $y$ :

$$y = \frac{\frac{x^5}{5} + 2x^2 + C}{\sqrt{1-x^2}}$$

So, that's the general solution. Now, apply the initial condition  $f(0) = 0$ . Let's plug  $x = 0$  into the solution:

$$y(0) = \frac{0 + 0 + C}{1} = C$$

But  $y(0) = 0$ , so  $C = 0$ .

Therefore, the particular solution is:

$$y = \frac{\frac{x^5}{5} + 2x^2}{\sqrt{1-x^2}} = \frac{x^5 + 10x^2}{5\sqrt{1-x^2}}$$

So,  $f(x) = \frac{x^5 + 10x^2}{5\sqrt{1-x^2}}$

Now, the next step is to compute

$$6 \int_{-1/2}^{1/2} f(x) dx = 2\pi - \alpha$$

Given:

$$f(x) = \frac{x^5 + 10x^2}{5\sqrt{1-x^2}} = \frac{x^5}{5\sqrt{1-x^2}} + \frac{2x^2}{\sqrt{1-x^2}}$$

So the integral becomes:

$$\int_{-1/2}^{1/2} \left( \frac{x^5}{5\sqrt{1-x^2}} + \frac{2x^2}{\sqrt{1-x^2}} \right) dx$$

Split into two integrals:

$$\frac{1}{5} \int_{-1/2}^{1/2} \frac{x^5}{\sqrt{1-x^2}} dx + 2 \int_{-1/2}^{1/2} \frac{x^2}{\sqrt{1-x^2}} dx$$

Note: The first integrand is an odd function (since  $x^5$  is odd), and the limits are symmetric, so the integral is zero.

So we compute:

$$2 \int_{-1/2}^{1/2} \frac{x^2}{\sqrt{1-x^2}} dx = 4 \int_0^{1/2} \frac{x^2}{\sqrt{1-x^2}} dx$$

Use the substitution  $x = \sin \theta$ ,  $dx = \cos \theta d\theta$ ,  $\sqrt{1-x^2} = \cos \theta$ . When  $x = 0$ ,  $\theta = 0$ ; when  $x = \frac{1}{2}$ ,  $\theta = \frac{\pi}{6}$

So the integral becomes:

$$\begin{aligned} \int_0^{\pi/6} \sin^2 \theta d\theta &= \frac{1}{2} \int_0^{\pi/6} (1 - \cos 2\theta) d\theta = \frac{1}{2} \left[ \theta - \frac{\sin 2\theta}{2} \right]_0^{\pi/6} \\ &= \frac{1}{2} \left( \frac{\pi}{6} - \frac{\sin(\pi/3)}{2} \right) = \frac{1}{2} \left( \frac{\pi}{6} - \frac{\sqrt{3}}{4} \right) = \frac{\pi}{12} - \frac{\sqrt{3}}{8} \end{aligned}$$

Then,

$$\int_{-1/2}^{1/2} f(x) dx = \frac{\pi}{3} - \frac{\sqrt{3}}{2}$$

Now,

$$6 \int_{-1/2}^{1/2} f(x) dx = 6 \left( \frac{\pi}{3} - \frac{\sqrt{3}}{2} \right) = 2\pi - 3\sqrt{3}$$

Given  $6 \int_{-1/2}^{1/2} f(x) dx = 2\pi - \alpha$ , we conclude:

$$\alpha = 3\sqrt{3} \Rightarrow \alpha^2 = 27$$

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</think>

Given the differential equation:

$$\frac{dy}{dx} + \frac{xy}{x^2-1} = \frac{x^4+4x}{\sqrt{1-x^2}}, \quad -1 < x < 1$$

with the initial condition  $f(0) = 0$ , we need to find  $\alpha^2$  where  $6 \int_{-1/2}^{1/2} f(x) dx = 2\pi - \alpha$ .

Figure 5: Response from DeepSeek R1 Distill Qwen 7B (Part 2 of 3)

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First, we solve the differential equation using the integrating factor method. The integrating factor is:

$$\mu(x) = \exp\left(\int \frac{x}{x^2-1} dx\right) = \sqrt{1-x^2}$$

Multiplying through by the integrating factor, we get:

$$\sqrt{1-x^2} \frac{dy}{dx} + \frac{x}{\sqrt{1-x^2}} y = x^4 + 4x$$

This simplifies to:

$$\frac{d}{dx} (\sqrt{1-x^2} y) = x^4 + 4x$$

Integrating both sides:

$$\sqrt{1-x^2} y = \int (x^4 + 4x) dx = \frac{x^5}{5} + 2x^2 + C$$

Applying the initial condition  $f(0) = 0$ , we find  $C = 0$ . Thus, the solution is:

$$y = \frac{\frac{x^5}{5} + 2x^2}{\sqrt{1-x^2}} = \frac{x^5 + 10x^2}{5\sqrt{1-x^2}}$$

Next, we compute the integral:

$$6 \int_{-1/2}^{1/2} f(x) dx$$

We split the integral into two parts:

$$6 \left( \int_{-1/2}^{1/2} \frac{x^5}{5\sqrt{1-x^2}} dx + \int_{-1/2}^{1/2} \frac{2x^2}{\sqrt{1-x^2}} dx \right)$$

The first integral is zero because it is an odd function. The second integral is computed using the substitution  $x = \sin \theta$ :

$$4 \int_0^{\pi/6} \sin^2 \theta d\theta = 4 \left( \frac{\pi}{12} - \frac{\sqrt{3}}{8} \right) = \frac{\pi}{3} - \frac{\sqrt{3}}{2}$$

Thus,

$$6 \left( \frac{\pi}{3} - \frac{\sqrt{3}}{2} \right) = 2\pi - 3\sqrt{3}$$

Given  $6 \int_{-1/2}^{1/2} f(x) dx = 2\pi - \alpha$ , we find  $\alpha = 3\sqrt{3}$ . Therefore,  $\alpha^2 = (3\sqrt{3})^2 = 27$ .

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Figure 6: Response from DeepSeek R1 Distill Qwen 7B (Part 3 of 3)

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To solve the given differential equation  $\frac{dy}{dx} + \frac{xy}{x^2-1} = \frac{x^4+4x}{\sqrt{1-x^2}}$  with the initial condition  $f(0) = 0$ , we start by identifying it as a first-order linear differential equation. The standard form of a first-order linear differential equation is  $\frac{dy}{dx} + P(x)y = Q(x)$ , where  $P(x) = \frac{x}{x^2-1}$  and  $Q(x) = \frac{x^4+4x}{\sqrt{1-x^2}}$ .

The integrating factor  $\mu(x)$  is given by  $\mu(x) = e^{\int P(x) dx} = e^{\int \frac{x}{x^2-1} dx}$ . To find this integral, we use the substitution  $u = x^2 - 1$ , so  $du = 2x dx$ . Thus,  $\int \frac{x}{x^2-1} dx = \frac{1}{2} \int \frac{1}{u} du = \frac{1}{2} \ln |u| = \frac{1}{2} \ln |x^2 - 1|$ . Therefore, the integrating factor is  $\mu(x) = e^{\frac{1}{2} \ln |x^2-1|} = \sqrt{|x^2-1|} = \sqrt{1-x^2}$  since  $x$  is in the interval  $(-1, 1)$ .

Multiplying both sides of the differential equation by the integrating factor  $\sqrt{1-x^2}$ , we get:

$$\sqrt{1-x^2} \frac{dy}{dx} + \frac{x}{\sqrt{1-x^2}} y = x^4 + 4x.$$

The left-hand side is the derivative of  $y\sqrt{1-x^2}$ :

$$\frac{d}{dx} (y\sqrt{1-x^2}) = x^4 + 4x.$$

Integrating both sides with respect to  $x$ , we have:

$$y\sqrt{1-x^2} = \int (x^4 + 4x) dx.$$

The integral on the right-hand side is:

$$\int x^4 dx + \int 4x dx = \frac{x^5}{5} + 2x^2 + C.$$

Thus,

$$y\sqrt{1-x^2} = \frac{x^5}{5} + 2x^2 + C.$$

Solving for  $y$ , we get:

$$y = \frac{\frac{x^5}{5} + 2x^2 + C}{\sqrt{1-x^2}}.$$

Using the initial condition  $f(0) = 0$ , we substitute  $x = 0$  and  $y = 0$ :

$$0 = \frac{0 + 0 + C}{\sqrt{1-0^2}} = C.$$

So,  $C = 0$ , and the solution is:

$$y = \frac{x^5 + 10x^2}{5\sqrt{1-x^2}}.$$

We need to find  $6 \int_{-1/2}^{1/2} f(x) dx$ . Since  $f(x) = \frac{x^5 + 10x^2}{5\sqrt{1-x^2}}$ , we have:

$$6 \int_{-1/2}^{1/2} \frac{x^5 + 10x^2}{5\sqrt{1-x^2}} dx = \frac{6}{5} \int_{-1/2}^{1/2} \frac{x^5 + 10x^2}{\sqrt{1-x^2}} dx.$$

We can split this integral into two parts:

$$\frac{6}{5} \left( \int_{-1/2}^{1/2} \frac{x^5}{\sqrt{1-x^2}} dx + 10 \int_{-1/2}^{1/2} \frac{x^2}{\sqrt{1-x^2}} dx \right).$$

The first integral is zero because  $\frac{x^5}{\sqrt{1-x^2}}$  is an odd function integrated over a symmetric interval. So, we only need to evaluate the second integral:

$$\frac{6}{5} \cdot 10 \int_{-1/2}^{1/2} \frac{x^2}{\sqrt{1-x^2}} dx = 12 \int_{-1/2}^{1/2} \frac{x^2}{\sqrt{1-x^2}} dx.$$

Since  $\frac{x^2}{\sqrt{1-x^2}}$  is an even function, we can rewrite the integral as:

$$12 \cdot 2 \int_0^{1/2} \frac{x^2}{\sqrt{1-x^2}} dx = 24 \int_0^{1/2} \frac{x^2}{\sqrt{1-x^2}} dx.$$

To evaluate this integral, we use the substitution  $x = \sin \theta$ , so  $dx = \cos \theta d\theta$  and when  $x = 0$ ,  $\theta = 0$ , and when  $x = 1/2$ ,  $\theta = \frac{\pi}{6}$ . The integral becomes:

$$24 \int_0^{\pi/6} \frac{\sin^2 \theta}{\sqrt{1-\sin^2 \theta}} \cos \theta d\theta = 24 \int_0^{\pi/6} \frac{\sin^2 \theta}{\cos \theta} \cos \theta d\theta = 24 \int_0^{\pi/6} \sin^2 \theta d\theta.$$

Using the identity  $\sin^2 \theta = \frac{1-\cos 2\theta}{2}$ , we get:

$$24 \int_0^{\pi/6} \frac{1-\cos 2\theta}{2} d\theta = 12 \int_0^{\pi/6} (1-\cos 2\theta) d\theta = 12 \left[ \theta - \frac{\sin 2\theta}{2} \right]_0^{\pi/6}.$$

Evaluating this, we have:

$$12 \left( \frac{\pi}{6} - \frac{\sin \frac{\pi}{3}}{2} - 0 + 0 \right) = 12 \left( \frac{\pi}{6} - \frac{\sqrt{3}}{4} \right) = 2\pi - 3\sqrt{3}.$$

We are given that  $6 \int_{-1/2}^{1/2} f(x) dx = 2\pi - \alpha$ , so  $2\pi - 3\sqrt{3} = 2\pi - \alpha$ . Therefore,  $\alpha = 3\sqrt{3}$ , and  $\alpha^2 = (3\sqrt{3})^2 = 27$ .

The final answer is:

$$\boxed{27}.$$

Figure 7: Response from Aryabhata 1.0 (Part 1 of 1)