OpenAI Codex CLI Training

AI-Powered Terminal Coding Agent

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Course Overview

5-Hour Hands-On Workshop

- Installation and authentication strategies
- Terminal UI and navigation
- Sandbox modes and approval policies
- Real-world coding projects

Topics We'll Cover

- Advanced TOML configuration
- MCP services integration
- Memory with AGENTS.md
- Custom prompts and profiles
- Multi-model provider support

Prerequisites

- Command-line experience
- Basic programming knowledge
- Git familiarity
- Docker (for advanced exercises)

What is OpenAI Codex CLI?

Lightweight Terminal-Based Coding Agent

Key Features

- Multi-model support (GPT, Claude, Ollama)
- Built-in safety with sandbox modes
- Rich configuration system
- Model Context Protocol (MCP) integration

Advanced Capabilities

- Session persistence and resumption
- Custom prompts and profiles
- CI/CD compatible
- Headless execution

Authentication Options

ChatGPT Account (Recommended)

- Uses existing ChatGPT subscription
- Zero Data Retention (ZDR)
- Simplified login flow

API Key

- Direct API access
- Pay-per-use pricing
- More configuration required

Model Support

- OpenAI GPT models (default)
- Anthropic Claude via API
- Local models via Ollama
- Custom providers via configuration

Installation Methods

```
# NPM (recommended)
npm install -g @openai/codex

# Homebrew (macOS/Linux)
brew install codex

# Direct binary download
# Visit: https://github.com/openai/codex/releases
```

Verify Installation

```
codex --version
```

Configuration Locations

- **Config**: `~/.codex/config.toml`
- **Prompts**: `~/.codex/prompts/`
- **Logs**: `~/.codex/log/`

ChatGPT Account Login

```
# Interactive login
codex login

# Headless login for servers
codex login --headless
```

API Key Authentication

```
# Set environment variable
export OPENAI_API_KEY="your-key"

# Or configure in TOML
echo 'api_key = "your-key"' >> ~/.codex/config.toml
```

Verify Authentication

```
codex "Hello, are you working?"
```

Starting Codex

```
# Interactive mode (default)
codex

# With initial prompt
codex "explain this codebase"

# Execute and exit mode
codex exec "generate a README"
```

Key Bindings

- `Enter` - Submit prompt
- `Ctrl+C` - Cancel current operation
- `Ctrl+D` - Exit Codex
- `Tab` - Autocomplete
- `/` - Access slash commands

Slash Commands

- `/status` - Show session info & token usage
- `/diff` - Review all pending changes
- `/clear` - Clear conversation history
- `/save` - Save current session
- `/help` - Show available commands
- `/settings` - Adjust runtime settings

/diff Command - Review Changes

```
--- a/src/main.py
+++ b/src/main.py
@@ -10,7 +10,9 @@ def process_data(input_file):
-    data = json.load(f)
+    with open(input_file, 'r') as f:
+        data = json.load(f)
     return data

3 files changed, 47 insertions(+), 12 deletions(-)
```

Review line-by-line before approving!

/status Command (v0.35+)

Shows comprehensive session information:

```
Current model: gpt-4
Session ID: abc123
Token usage: 15,432 / 128,000
Cost estimate: $0.46
Time elapsed: 12m 34s
```

Search Your Codebase

```
# Fast text search with ripgrep
rg "TODO"
rg "authenticate"
rg "database connection"
```

- Respects .gitignore and runs fast on large repos
- Pipe matches into Codex for follow-up analysis
- Keep the agent focused by sharing only relevant snippets
- Great starting point for exploration and debugging

Web Search Capabilities

```toml
# ~/.codex/config.toml
[tools]
web_search = true
```

- Search the entire web for solutions
- Find latest documentation and tutorials
- Access Stack Overflow answers
- Get real-time information
- Research libraries and frameworks

Using Web Search

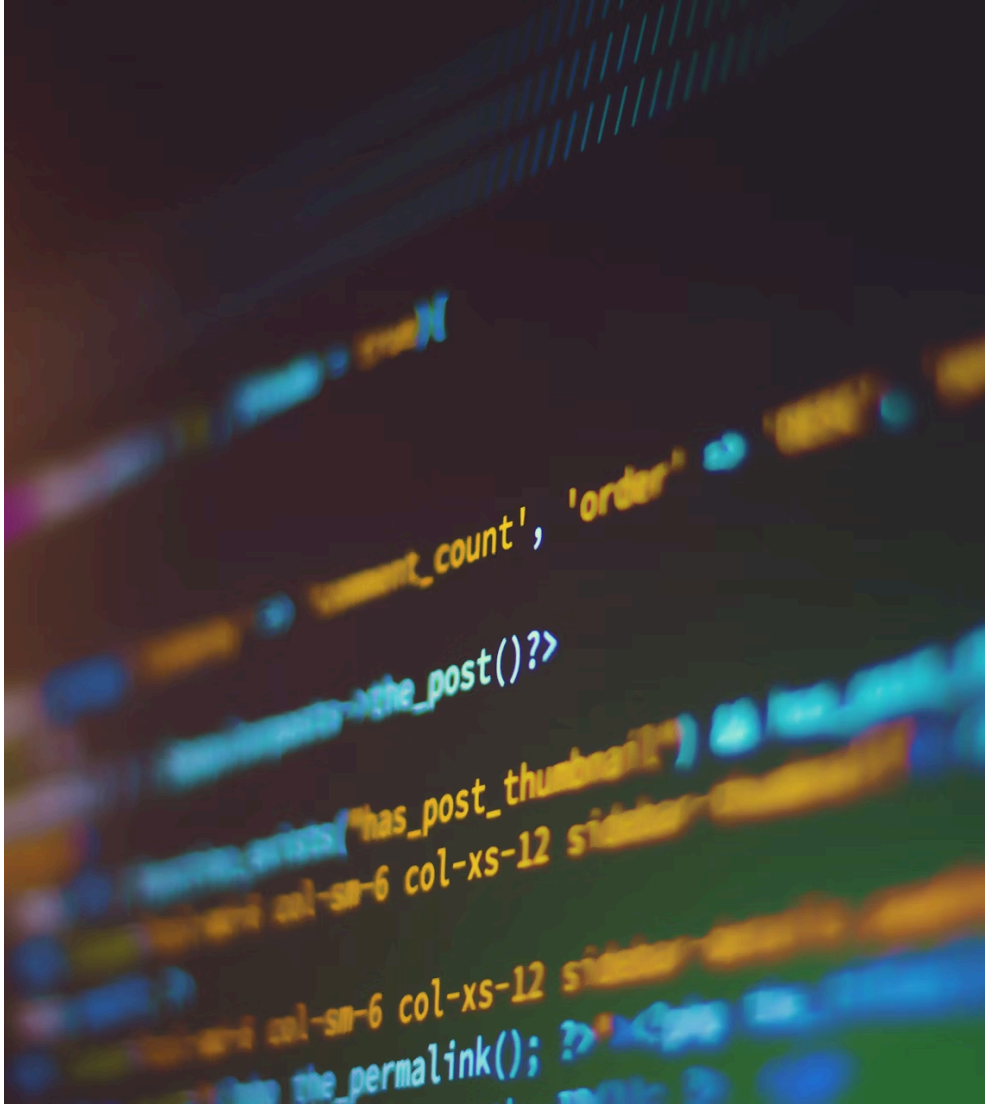
```
# In interactive mode, Codex can search the web
codex
> "Search for the latest React 18 features"
> "Find Python async/await best practices"
> "What are the breaking changes in Spring Boot 3?"
```

- Automatic web search when needed
- Current information beyond training cutoff
- Verify solutions with official docs

Core Features

Essential Capabilities

Master the fundamentals



Sandbox Modes

- **read-only** - No file modifications
- **workspace-write** - Default; writes limited to the workspace
- **danger-full-access** - No sandboxing (use carefully!)

Approval Policies

- **untrusted** - Run only trusted commands without prompting
- **on-request** - Approve risky actions
- **on-failure** - Approve only on failures
- **never** - No approval prompts

Setting Safety Options

```
# Set sandbox mode
codex --sandbox read-only

# Set approval policy
codex --ask-for-approval on-request

# Bypass all safety (dangerous!)
codex --dangerously-bypass-approvals-and-sandbox
```

Project Memory: AGENTS.md

Automatic Context Loading

- Place `AGENTS.md` in project root
- Loaded automatically with first prompt
- Configurable size limit (default: 32KB)

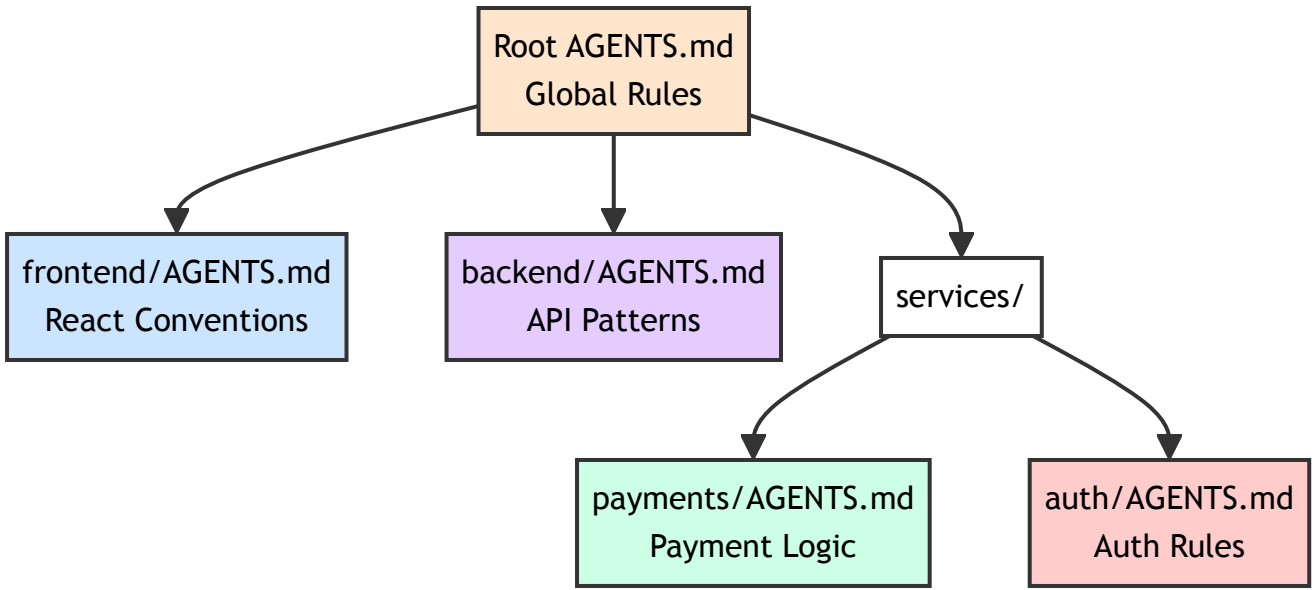
Example AGENTS.md

```
# Project: E-Commerce Platform

## Tech Stack
- Backend: Node.js + Express
- Database: PostgreSQL
- Frontend: React + TypeScript
```

AGENTS.md Best Practices

```
## Conventions
- Use async/await for all async operations
- Follow RESTful API patterns
- Write tests for all new features

## Current Focus
Working on payment integration with Stripe
```

Hierarchical AGENTS.md (v0.39+)



Rules cascade: Subfolder overrides parent

Context Cascade Benefits

- Global rules apply everywhere
- Subfolder rules override parent
- Each team owns their conventions
- Frontend/backend stay independent
- Microservices maintain autonomy

Custom Prompts

Creating Custom Prompts

1. Create `.md` file in `~/.codex/prompts/`
2. Access via slash commands
3. Reusable across projects

Example Custom Prompt

```
# ~/.codex/prompts/refactor.md
Refactor the selected code following these principles:
1. Extract complex logic into small functions
2. Use meaningful variable names
3. Add appropriate error handling
```

Prompt Library Highlights

- Prebuilt prompts live in `~/.codex/prompts/` (see repo `prompts/README.md`)
- Core templates: `refactor`, `security-audit`, `test-gen`, `pr-review`, `api-upgrade`, `perf-fix`
- Customize or fork them for your team's workflow and slash commands

```
/refactor
/security-audit
/test-gen
/pr-review
/api-upgrade
/perf-fix
```


```
/refactor
/security-audit
/test-gen
/pr-review
/api-upgrade
/perf-fix
```

Prompt Arguments Workaround

Codex doesn't support `$ARGUMENTS` like Claude Code, but you can use shell scripts:

```
#!/bin/bash
# ~/.codex/scripts/review-file.sh

FILE=$1
FOCUS=$2

cat > /tmp/review-prompt.md << EOF
Review the file ${FILE} focusing on ${FOCUS}:
- Check for bugs and errors
- Suggest improvements
- Rate code quality
EOF

codex exec "$(cat /tmp/review-prompt.md)"
```

Usage: `./review-file.sh UserService.java security`

Configuration Profiles

Define Multiple Profiles

```
# ~/.codex/config.toml

[profiles.production]
model = "gpt-4"
approval_policy = "on-request"
sandbox_mode = "workspace-write"

[profiles.development]
model = "gpt-4o-mini"
approval_policy = "never"
sandbox_mode = "danger-full-access"
```

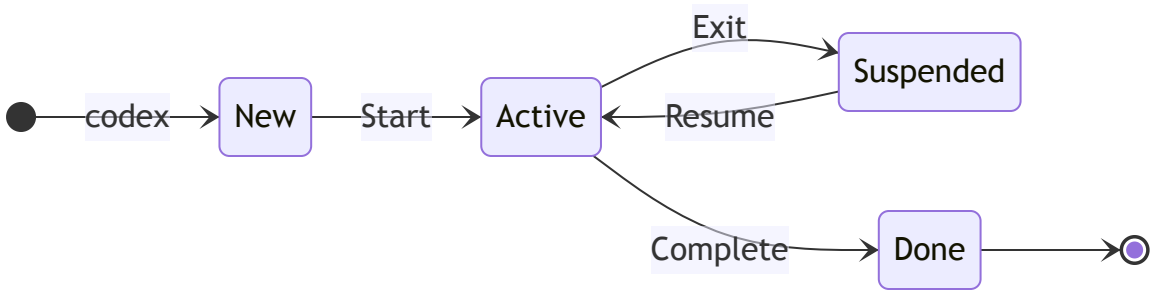
Using Profiles

```
codex --profile production
codex --profile development
codex --profile testing
```

Resume Previous Sessions

```
# Open picker to choose a session
codex resume

# Resume the most recent session automatically
codex resume --last

# Resume a specific session by id
codex resume SESSION_ID
```

Session Lifecycle



Commands: `codex`, `codex resume`, `codex apply`

Session Commands

```
# Interactive session picker
codex resume

# Jump straight to the most recent session
codex resume --last

# Apply the last diff from the active session
codex apply
```

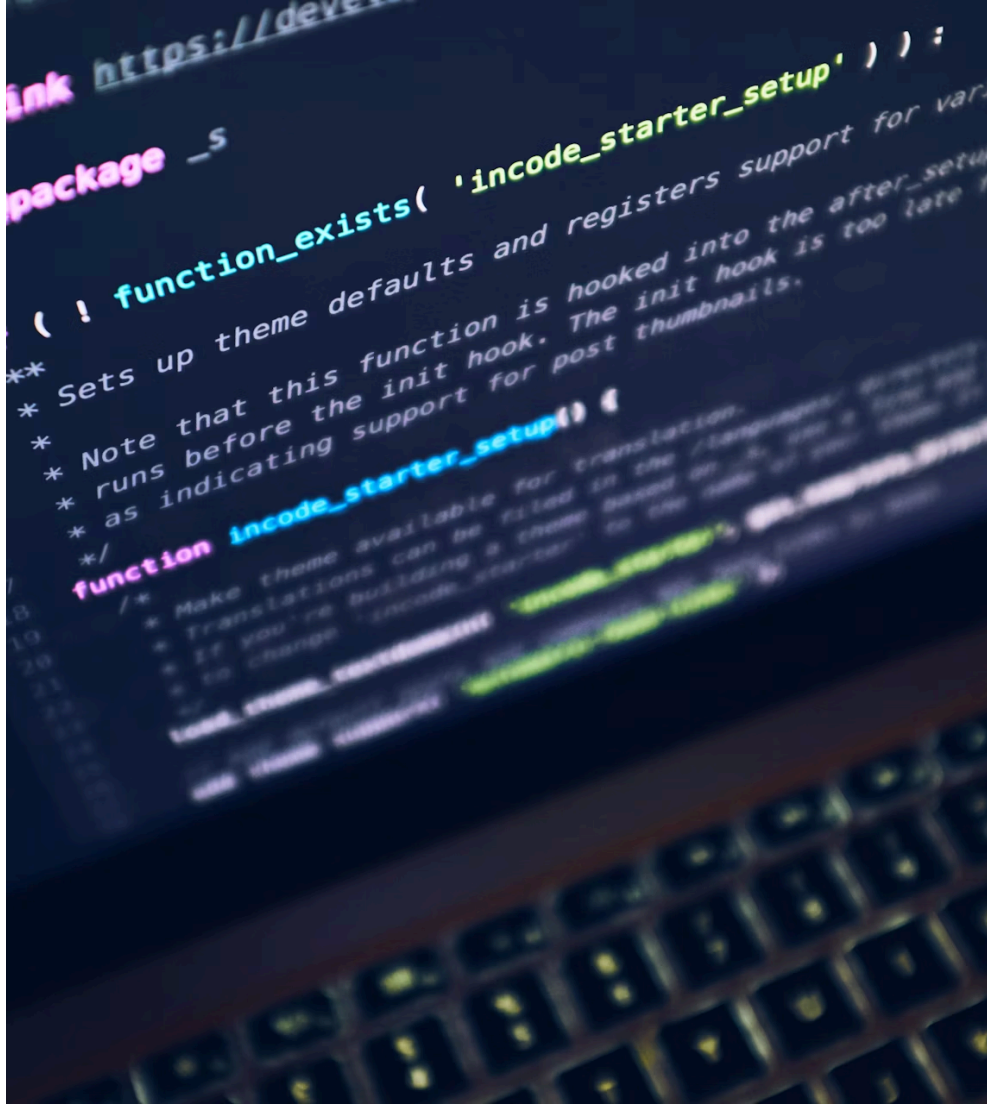
Non-Interactive Sessions

```
# Run in CI/CD pipeline
codex exec "update dependencies and fix breaking changes"

# Note: For resuming, use the regular command
codex resume
```

Advanced Features

Power User Tools

Unlock full potential



Model Context Protocol (MCP)

Configure MCP Servers

GitHub MCP Server

```
[mcp_servers.github]
command = "npx"
args = ["@modelcontextprotocol/server-github"]
env = { GITHUB_TOKEN = "${GITHUB_TOKEN}" }
```

Database MCP Server

```
[mcp_servers.postgres]
command = "npx"
args = ["@modelcontextprotocol/server-postgres"]
env = { CONNECTION_STRING = "${DATABASE_URL}" }
```

MCP Startup Guardrails (v0.31+)

Prevent flaky tools from freezing Codex:

```
[mcp_servers.github]
command = "npx"
args = ["@modelcontextprotocol/server-github"]
startup_timeout_ms = 15000  # Abort after 15 seconds
```

MCP Timeout Benefits

- Clean abort when helpers fail to boot
- Prevents entire run from freezing
- Better error messages
- Faster feedback on configuration issues

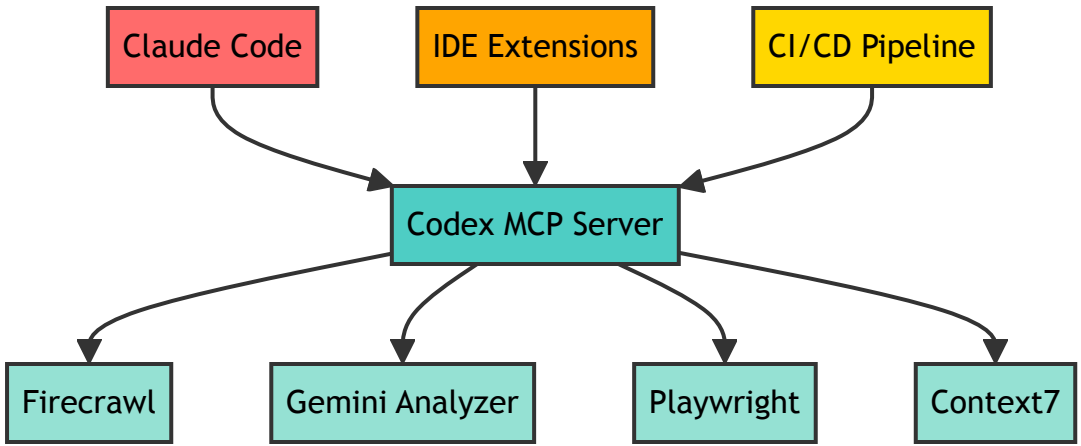
MCP Usage

- Automatically available when configured
- Access external tools and data
- Extend Codex capabilities

Running Codex as MCP Server

```
# Modern approach (v0.37+)
codex mcp --config ~/.codex/config.toml

# Legacy approach
codex serve --port 8080
```

MCP Architecture



MCP Server Benefits

The `codex mcp` command exposes Codex as a tool:

- Other agents can call Codex workflows
- IDEs can integrate without plugins
- Claude Code can use as sub-agent
- Mix model strengths (GPT + Claude)

Why Codex as Sub-Agent?

- Leverage GPT-5-Codex for complex tasks
- Use Codex’s specialized prompts
- Access different model providers
- Unified approval/sandbox policies

Integration Example

```
# Add Codex as MCP server in Claude Code
claude mcp add codex -- codex mcp

# List MCP servers
claude mcp list

# Remove if needed
claude mcp remove codex
```

Integration Options

- Connect from other MCP clients
- Use in multi-agent workflows
- Integrate with IDEs

Example Client Connection

```
const client = new MCPClient({
  url: 'http://localhost:8080',
  capabilities: ['code-generation', 'review']
});
```

Multi-Model Provider Support

Configure Alternative Providers

Anthropic Claude

```toml
[providers.anthropic]
type = "anthropic"
api_key = "${ANTHROPIC_API_KEY}"
model = "claude-3-opus-20240229"
```

Local Ollama

```
[providers.ollama]
type = "ollama"
base_url = "http://localhost:11434"
model = "codellama"
```

Azure OpenAI

```
[providers.azure]
type = "azure-openai"
api_key = "${AZURE_API_KEY}"
endpoint = "https://myinstance.openai.azure.com"
deployment = "gpt-4"
```

Switch Providers

```
codex --provider anthropic
codex --provider ollama
codex --provider azure
```

Enable Detailed Logging

```
# Set log level
export RUST_LOG=debug
codex

# Trace level (maximum detail)
export RUST_LOG=trace
codex
```

Log Locations

- Interactive: `~/.codex/log/codex-tui.log`
- Non-interactive: stderr output
- Custom: Redirect with shell operators

Debug Configuration

```
# ~/.codex/config.toml
[logging]
level = "debug"
file = "/path/to/custom.log"
```

CI/CD & Automation

- GitHub Actions skeleton lives in repo (`automation/github-actions.yml`)
- Typical steps: checkout → install Codex → authenticate → `codex exec` tasks → upload artifacts
- Cron ideas: weekly security sweep, dependency refresh, monthly cleanup (scripts provided)
- Guardrails: run on branches, review PRs before merge, notify on failures

```
# Fail-fast pipeline
git pull && \
codex exec "migrate database schema" && \
npm test

# Weekly cron example
0 2 * * 1 cd /path/to/repo && \
  codex exec "weekly security audit"

# Chain commands to stop on failure
npm install && \
codex exec "fix any TypeScript errors" && \
npm run build
```

Advanced TOML Configuration

```toml
# ~/.codex/config.toml
model = "gpt-4o"
model_provider = "openai"
approval_policy = "on-request"
sandbox_mode = "workspace-write"

[tools]
web_search = true
```

Environment & Notifications

```toml
[notification]
program = "notify-send"
args = ["Codex", "Task completed"]

[shell_environment]
NODE_ENV = "development"
PYTHONPATH = "/usr/local/lib/python3.9"
```

Shell Environment Policies

- **inherit** - Use parent shell environment
- **explicit** - Only specified variables
- **minimal** - Basic environment only

Environment Configuration

```
# Inherit all variables
shell_environment_policy = "inherit"

# Explicit variables only
shell_environment_policy = "explicit"
```

Explicit Environment

```
[shell_environment]
PATH = "/usr/local/bin:/usr/bin:/bin"
HOME = "/home/user"
LANG = "en_US.UTF-8"
```

Security Considerations

- Use `explicit` for production
- Use `inherit` for development
- Never expose secrets in config

Notification Options

- Notifications live in `[notification]` (see repo for full examples)
- macOS: `program="osascript"`, Linux: `program="notify-send"`, Webhook: `program="curl"`
- Triggers: task completion, approval prompts, error conditions (configurable)

Practical Exercises

Hands-On Labs

Learn by doing

Exercise Structure

Three Main Categories

1. Generate from Scratch

- Spring Boot REST API
- Python CLI tool
- React dashboard

2. Refactor Existing Code

- Legacy Java modernization
- Python code quality improvements
- TypeScript migration

3. Multi-Language Projects

- Microservices architecture
- Full-stack application
- Data pipeline

Each Exercise Includes

- Starting code
- Requirements
- Expected outcomes
- Solution walkthrough

Lab 1: Spring Boot API

- Objective: Build a Spring Boot 3 task-management REST API end-to-end
- Timebox: 60–90 minutes
- Workspace: `exercises/java-spring-boot`
- Instructions: open `exercises/java-spring-boot/README.md`

Lab 2: Python Refactoring

- Objective: Modernize legacy Python code with clean architecture and tests
- Timebox: 45–60 minutes
- Workspace: `exercises/python-refactoring`
- Instructions: open `exercises/python-refactoring/README.md`

Lab 3: React TypeScript Forms

- Objective: Ship a production-ready registration flow with React, TypeScript, and Zod
- Timebox: 45–60 minutes
- Workspace: `exercises/react-forms`
- Instructions: open `exercises/react-forms/README.md`

Lab 4: Microservices

- Objective: Build an event-driven multi-language microservices system
- Timebox: 90–120 minutes
- Workspace: `exercises/microservices`
- Instructions: open `exercises/microservices/README.md`

Lab 5: Database Migration

- Objective: Use Codex + MCP tools to modernize a legacy PostgreSQL schema
- Timebox: 60–75 minutes
- Workspace: Bring an existing service repo or the sample DB provided in class
- Instructions: follow the facilitator handout for the Database Migration lab

Lab 6: AI Code Review

- Objective: Automate pull-request reviews with Codex in CI/CD
- Timebox: 45 minutes
- Workspace: Use any Git repo with open PRs (sample repo provided during workshop)
- Instructions: follow the AI Code Review lab handout / `ai-review` workflow template

Advanced Exercise: Full-Stack E-Commerce

- Objective: Combine backend, frontend, and DevOps workflows into a production-style storefront
- Suggested scope: Spring Boot API + React storefront + CI/CD automation
- Workspace: Remix outputs from Labs 1–4 or start fresh from the provided capstone brief
- Instructions: follow the capstone handout distributed during the workshop

Best Practices

Professional Workflows

Enterprise-ready patterns

Review Changes Before Approving

- Codex displays unified diffs automatically
- Use `/diff` to see all pending changes
- Review line-by-line for unintended edits
- Check file statistics (insertions/deletions)
- Catch mistakes before they land in codebase

Pro tip: Always review diffs for:

- Accidental deletions
- Unrelated file changes
- Security implications

Security Best Practices

Sandbox Configuration by Environment

Development Profile

```
[profiles.dev]
sandbox_mode = "danger-full-access"
approval_policy = "never"
```

Staging Profile

```
[profiles.staging]
sandbox_mode = "workspace-write"
approval_policy = "on-request"
```

Production Profile

```
[profiles.prod]
sandbox_mode = "read-only"
approval_policy = "on-request"
```

Security Guidelines

- Never store API keys in config files
- Use environment variables for secrets
- Enable approval for production
- Regular audit of generated code
- Restrict network access in sandbox

Team Collaboration

Shared Configuration

Project AGENTS.md

```
# Team: Platform Engineering
## Conventions
- PR reviews required for all changes
- Follow company style guide
- Security scanning mandatory
- 80% test coverage minimum
```

Current Sprint Context

```
## Current Sprint
- Migrating to Kubernetes
- Implementing OAuth 2.0
```

Shared Prompts Repository

```
# Clone team prompts
git clone team-repo/codex-prompts ~/.codex/prompts

# Keep synchronized
cd ~/.codex/prompts && git pull
```

Model Selection Strategy

```
[profiles.quick]
model = "gpt-3.5-turbo"  # Fast responses

[profiles.complex]
model = "gpt-4"  # Complex reasoning
```

Local Models

```
[profiles.local]
provider = "ollama"
model = "codellama"  # No API costs
```

Optimization Tips

- Use smaller models for simple tasks
- Cache responses with session resumption
- Batch similar operations
- Use local models for sensitive data

Troubleshooting Guide

Common Issues & Solutions

Authentication Failures

```
# Clear cached credentials
rm -rf ~/.codex/auth

# Re-authenticate
codex login --headless
```

Sandbox Errors

```
# Confirm sandbox configuration
grep sandbox_mode ~/.codex/config.toml

# Bypass for Docker environments
codex --dangerously-bypass-approvals-and-sandbox
```

MCP Connection Issues

```
# Test MCP server
npx @modelcontextprotocol/server-test

# Enable debug logging
RUST_LOG=trace codex
```

VS Code Integration

```
{
  "tasks": [{
    "label": "Codex Review",
    "type": "shell",
    "command": "codex exec 'Review ${file} for issues'"
  }]
}
```

Git Hooks

```
#!/bin/bash
# .git/hooks/pre-commit
codex -n --profile review \
  "Check staged files for security issues"
```

Make Integration

```
review:
  codex exec "Review all changes since last commit"

generate-tests:
  codex exec "Generate missing unit tests"
```

Structured Logging

```
[logging]
level = "info"
format = "json"
file = "/var/log/codex/codex.log"
```

Metrics Configuration

```
[metrics]
enable = true
endpoint = "http://metrics.internal:9090"
```

Log Analysis

```
# Parse JSON logs
cat ~/.codex/log/codex-tui.log | jq '.level == "error"'

# Monitor in real-time
tail -f ~/.codex/log/codex-tui.log | grep ERROR
```

Build Your Own MCP Server

```
// custom-mcp-server.js
import { MCPServer } from '@modelcontextprotocol/sdk';

const server = new MCPServer({
  name: 'custom-tools',
  version: '1.0.0'
});
```

MCP Tool Definition

```
tools: [{
  name: 'database-query',
  description: 'Execute database queries',
  handler: async (params) => {
    return { result: 'Query executed' };
  }
}]
```

Register Custom Server

```
[mcp_servers.custom]
command = "node"
args = ["./custom-mcp-server.js"]
```

From GitHub Copilot

- Export commonly used snippets
- Convert to Codex prompts
- Leverage session persistence

From Claude Code

```
# Import Claude memory
cp ../claude-code/.claude/CLAUDE.md ./AGENTS.md

# Convert slash commands
for f in ../claude-code/.claude/commands/*.md; do
  cp "$f" ~/.codex/prompts/
done
```

From Cursor/Codeium

- Migrate project context
- Recreate custom instructions
- Set up equivalent workflows

Recent Features (v0.30-0.39)

Version 0.30-0.39 Highlights

- MCP startup timeouts (v0.31)
- Token usage in /status command (v0.35)
- GPT-5-Codex high reasoning mode (v0.36)
- Network allowlists for testing (v0.36)
- Simplified MCP server: `codex mcp` (v0.37)
- Hierarchical AGENTS.md cascading (v0.39)
- Enhanced error handling
- Improved session management
- Performance optimizations

MCP Robustness (v0.31+)

Always add timeout to MCP servers:

```
[mcp_servers.your_server]
command = "your-command"
startup_timeout_ms = 15000  # Recommended
```

Advanced Model Control (v0.36+)

Use GPT-5-Codex for complex, long-running tasks:

```
codex -m gpt-5-codex -c model_reasoning_effort='high'
```

Or configure in TOML:

```
model_reasoning_effort = "high"  # minimal/low/medium/high
```

High Reasoning Mode Benefits

- Multi-hour work sessions allowed
- Iterates tests until green
- Deep problem-solving capability
- Automatic retry on failures
- Best for complex refactoring

When to Use High Reasoning

- Large test suite fixes
- Complex architectural changes
- Multi-file refactoring
- Performance optimizations
- Breaking change migrations

Network Access Control

Control network access in sandbox mode:

```
# ~/.codex/config.toml
[sandbox_workspace_write]
network_access = true  # Default: false
```

Note: Domain-specific allowlists may be available in v0.36+ (check release notes)

Network Control Benefits

- Offline by default for reproducibility
- Allow only specific staging APIs
- Prevent accidental external calls
- Maintain test isolation
- Control data exfiltration

Network Allowlist Use Cases

- Integration tests with staging APIs
- CI/CD pipelines with controlled access
- Development with specific endpoints
- Security-sensitive environments
- Reproducible test suites

Q1 2025 Roadmap

- Plugin ecosystem
- Visual Studio Code extension
- Enhanced MCP marketplace

Q2 2025 Roadmap

- Multi-agent coordination
- Real-time collaboration
- Advanced code analysis

Future Vision

- Voice control integration
- AR/VR code visualization
- Quantum computing support

Community Contributions

- Open source at github.com/openai/codex
- Feature requests welcome
- Plugin development SDK coming

Essential Commands

```
# Basic usage
codex                          # Interactive mode
codex exec "prompt"            # Execute task & exit
codex resume                   # Resume session
codex apply                    # Apply last diff
```

Configuration Commands

```
codex --profile production            # Use profile
codex --sandbox read-only             # Set sandbox
codex --ask-for-approval on-request   # Set approval
```

Advanced Commands

```
codex mcp --config ~/.codex/config.toml  # MCP server mode (v0.37+)
codex apply                              # Apply last diff
codex resume --last                      # Resume most recent session
```

Key Files

- Config: `~/.codex/config.toml`
- Prompts: `~/.codex/prompts/*.md`
- Memory: `./AGENTS.md`
- Logs: `~/.codex/log/`

Documentation & Code

📚 Official Documentation

`https://github.com/openai/codex/docs`

🐙 GitHub Repository

`https://github.com/openai/codex`

Course & Community

💻 Course Materials & Labs

`https://github.com/kousen/codex-training`

🆘 Community Support

`https://github.com/openai/codex/discussions`

📦 MCP Registry

`https://modelcontextprotocol.io/registry`

Discord & Office Hours

Discord Server

Join the Codex community for support and discussion

Weekly Office Hours

Every Thursday at 2 PM PST

Contributing

- Bug reports: GitHub Issues
- Feature requests: GitHub Discussions
- Code contributions: Pull Requests

Ecosystem

- MCP server templates
- Prompt libraries
- Configuration examples
- Integration guides

References & Credits

Newsletter Sources

MLearning.ai Art on Substack by @mlearning

- 100 OpenAI Codex CLI Tricks and Tips
- 30 Codex CLI Tips v0.30-0.39

Many advanced tips including:

- Command chaining with `&&`
- Scheduled maintenance automation
- Network allowlists
- High reasoning mode

Additional Resources

Official Sources

- Codex GitHub Repository
- Codex Documentation
- Model Context Protocol

Community

- Codex Discussions
- MCP Registry

Related Training

- Claude Code Training
- Junie Training Materials

Thank You!

Questions?

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