🔧 Setup (required once)

Variable / field	Purpose	How to provide
USER_AGENT	Identifies you in HTTP headers when scraping EDGAR.	Export `USER_AGENT="Ada <ada@example.com>"` before launching Jupyter **or** enter one when the setup cell prompts you.
OPENAI_API_KEY	Needed for any cell that calls OpenAI.	Export `OPENAI_API_KEY="sk-..."` **or** paste it when prompted in the setup cell.

In [1]:
```
# ╔═══════════════════════════════════════════════════╗
# ║  Setup — supply per-user secrets & identifiers    ║
# ╚═══════════════════════════════════════════════════╝
#
# Priority order for both variables
#   1. Environment variable            (best for CI / .env files)
#   2. Interactive prompt via getpass  (input hidden as you type)
#   3. Users can always reassign later in the notebook.
#
import os, sys
from getpass import getpass
from openai import OpenAI

# ---------- USER_AGENT ----------------------------------------
USER_AGENT = os.getenv("USER_AGENT")
if not USER_AGENT:                                  # fall back to hidden p
    USER_AGENT = getpass(
        "📝  Enter a USER_AGENT for EDGAR "
        '(e.g. "Ada Lovelace <ada@example.com>"): '
    ).strip()
    if not USER_AGENT:
        sys.exit("❌  USER_AGENT is required for EDGAR scraping.")

print("✅ USER_AGENT captured")

# ---------- OPENAI_API_KEY ------------------------------------
OPENAI_API_KEY = os.getenv("OPENAI_API_KEY")
if not OPENAI_API_KEY:
    try:
        OPENAI_API_KEY = getpass("🔑  Paste your OpenAI API key: ")
    except EOFError:
        sys.exit("❌  OPENAI_API_KEY is required for OpenAI calls.")

# ---------- OpenAI client -------------------------------------
client_openai = OpenAI(api_key=OPENAI_API_KEY)
print("✅ OpenAI client initialised")
```

```
✅ USER_AGENT captured
✅ OpenAI client initialised
```

In [2]:
```
# ╔═══════════════════════════════════════════════════╗
# ║ 1.  Imports                                       ║
# ╚═══════════════════════════════════════════════════╝
# ── standard library ──────────────────────────────
import argparse
```

```python
import datetime as dt
import importlib
import inspect
import json
import os
import pathlib
from pathlib import Path
import random
import re
import time
import uuid

# ─── third-party ──────────────────────────────
import boto3
import numpy as np
import openai
from openai import OpenAI
import pandas as pd
import pytz
import requests
import matplotlib.pyplot as plt

# Allow local helper modules (optional)
sys.path.insert(0, "/tmp")

# ╔═══════════════════════════════════════════════╗
# ║ 2.  Global configuration                      ║
# ╚═══════════════════════════════════════════════╝
RUN_ID   = uuid.uuid4().hex[:8]

# Validator tolerance  (±5 %)
LOWER_TOL_FACTOR = 0.95
UPPER_TOL_FACTOR = 1.05

# OpenAI
completions_model_choice = "gpt-4o"
OPENAI_API_KEY           = os.getenv("OPENAI_API_KEY")  # or Secrets Mana

max_tokens_api = 3000
retry_max_api = 50
temperature_api = 0
n_api = 1
sleep_time_lower_bound = 1.00
sleep_time_upper_bound = 1.10
sleep_time = random.uniform(sleep_time_lower_bound, sleep_time_upper_boun

# Cost model
MIN_WAGE   = 0.50                       # $ / reviewer-minute
MODEL_COST = {"accept": 0.001,
              "reject": 0.001,
              "defer" : 0.001,
              "unresolved": 0.001}

# ── choose where to drop artefacts ──────────────
OUT_DIR = Path.cwd() / "outputs"          # always visible in UI
OUT_DIR.mkdir(exist_ok=True)              # parents=True not needed here

GT_PATH   = OUT_DIR / "ground_truth.csv"
PASS1_OUT = OUT_DIR / f"ledger_pass1_{RUN_ID}.jsonl"
PASS2_OUT = OUT_DIR / f"ledger_pass2_{RUN_ID}.jsonl"
```

```
print("Working directory :", Path.cwd())
print("Artefacts will go :", OUT_DIR)

# Randomised back-off for OpenAI retries
sleep_time = random.uniform(1.00, 1.10)

# ╔═══════════════════════════════════════════════════════╗
# ╠ 3.  AWS / OpenAI clients                              ╣
# ╚═══════════════════════════════════════════════════════╝
s3 = boto3.client("s3")

# ╔═══════════════════════════════════════════════════════╗
# ╠ 4.  Static lookup tables & regex helpers              ╣
# ╚═══════════════════════════════════════════════════════╝
CACHE_DIR  = pathlib.Path(".sec_cache"); CACHE_DIR.mkdir(exist_ok=True)
INPUT_FILE_GROUND_TRUTH = "benchmark_queries_100_FY2021_FY2023.csv"
OUT_FILE_GROUND_TRUTH = OUT_DIR / "ground_truth.csv"

GAAP_MAP = {
    "Revenue": ["Revenues",
                "RevenueFromContractWithCustomerExcludingAssessedTax"],
    "Net Income": ["NetIncomeLoss"],
    "EBITDA": ["EarningsBeforeInterestTaxesDepreciationAmortization"],
    "Operating Income": ["OperatingIncomeLoss"],
    "Total Assets": ["Assets"],
    "EPS (diluted)": ["EarningsPerShareDiluted"],
    "Total Equity": ["StockholdersEquity"],
    "Shares Outstanding (diluted)": ["WeightedAverageNumberOfDilutedShare
    "Cash From Operations": ["NetCashProvidedByUsedInOperatingActivities"
}
CIK_LOOKUP = {
    "AAPL": "0000320193",
    "MSFT": "0000789019",
    "AMZN": "0001018724",
    "NVDA": "0001045810",
    "JPM":  "0000019617",
    "META": "0001326801",
    "GOOGL": "0001652044",
    "BRK.B": "0001067983",
    "KO":   "0000021344",
    "BAC":  "0000070858",
}

IDK_PATTERNS = [
    r"\bdo(?:\s+not|n't)\s+have\s+(?:access|the information)",
    r"\bno\s+.*real[- ]time\s+data",
    r"\bi\s+don't\s+have\s+the\s+specific",
    r"\bnot\s+available\b",
]

UNIT_MULT = {
    "trillion": 1e12, "tn": 1e12, "t": 1e12,
    "billion": 1e9,   "bn": 1e9,  "b": 1e9,
    "million": 1e6,   "mn": 1e6,  "m": 1e6,
    "thousand": 1e3,  "k": 1e3,
    "": 1.0,
}

num_re = re.compile(
```

```
    r"""
    (?P<sign>[-+]?)\s*
    (?P<int>(?:\d{1,3}(?:[,\s]\d{3})+|\d+))   # <-- re-ordered
    (?:\.(?P<frac>\d+))?
    \s*
    (?P<unit>trillion|bn|billion|mn|million|k|thousand|t|m|b)?
    \b
    """,
    re.IGNORECASE | re.VERBOSE,
)

# ╔═══════════════════════════════════════════════╗
# ║ 5.  Pre-allocate ledgers (empty lists)        ║
# ╚═══════════════════════════════════════════════╝
ledger_pass1 = []
ledger_pass2 = []

COLOR_PASS1 = "tab:blue"
COLOR_PASS2 = "tab:orange"
```

```
Working directory : /home/ec2-user/SageMaker/notebooks
Artefacts will go : /home/ec2-user/SageMaker/notebooks/outputs
```

In [3]:

```
def ask_openai(messages, max_tokens=max_tokens_api, stop=None, retry_max=
    """
    Wrapper around OpenAI Chat Completions.

    Parameters
    ----------
    messages : str | list[dict]
        Either a single prompt string or a chat-style list with 'role'/'c
    max_tokens : int
        Hard upper-bound on tokens to sample.
    stop : list[str] | None
        Forwarded to OpenAI to stop generation on any of these strings.
    retry_max : int
        Retry count on *any* exception.
    model : str
        Model name to pass through.

    Returns
    -------
    str
        Assistant's raw text reply (stripped of outer quotes).

    Notes
    -----
    * Converts a bare string into `[{"role": "user", "content": ...}]`.
    * Sleeps `sleep_time` seconds between retries (simple linear backoff)
    * Raises `Exception` if still failing after `retry_max` attempts.
    """

    if isinstance(messages, str):  # If the input is just a single string
        messages = [{"role": "user", "content": messages}]

    response = None
    retries = 0
    while retries < retry_max:
        try:
            response = client_openai.chat.completions.create(
```

```
                model=model,
                messages=messages,
                max_tokens=max_tokens,
                n=1,
                stop=stop,
                temperature=0
            )
            # Assuming the response is a pydantic model, we can access at
            content = response.choices[0].message.content.strip('"')
            return content
        except Exception as e:  # Catching any exception
            print(f"Error: {e}")
            retries += 1
            if retries >= retry_max:
                raise Exception("API call failed after maximum retries.")
            time.sleep(sleep_time)  # Wait for random seconds before retr

    raise Exception("Failed to receive a valid response from OpenAI API."

# ──────────────────────────────────────────────────────────────────────
# SEC DOWNLOAD + PARSING HELPERS
# ──────────────────────────────────────────────────────────────────────
def sec_companyfacts(cik: str) -> dict:
    """
    Download (or read cached) SEC CompanyFacts JSON for a given CIK.

    * Pads CIK to 10 digits.
    * Caches raw JSON under .sec_cache/CIK##########.json.
    * Sleeps `sleep_time` after a network hit to stay polite.
    """
    cik10 = cik.zfill(10)
    cache = CACHE_DIR / f"{cik10}.json"
    if cache.exists():
        return json.loads(cache.read_text())
    url = f"https://data.sec.gov/api/xbrl/companyfacts/CIK{cik10}.json"
    r = requests.get(url, headers={"User-Agent": USER_AGENT}, timeout=20)
    r.raise_for_status()
    cache.write_text(r.text)
    time.sleep(sleep_time)
    return r.json()

def best_10k_item(items: list[dict], fy: int):
    """
    Pick the most authoritative FY record from a list of XBRL facts.

    Priority order
    --------------
    1. Exact FY + form == '10-K'
    2. Exact FY + form == '10-K/A'
    3. If multiple matches, choose the one with the latest 'end' date.
    """
    same_fy = [it for it in items if it.get("fy") == fy]
    # split plain vs amended
    plain   = [it for it in same_fy if it.get("form") == "10-K"]
    amended = [it for it in same_fy if it.get("form") == "10-K/A"]

    def latest(lst):                    # helper returns latest by `end`
        return max(lst, key=lambda d: d.get("end", "0000-00-00"))

    if plain:
```

```
        return latest(plain)
    if amended:
        return latest(amended)
    return None


def fy_value(facts: dict, tags: list[str], fy: int):
    """
    Return (value, unit) for a metric in a specific fiscal year.

    Strategy
    --------
    * Strict FY match using `best_10k_item`.
    * If nothing found, fall back to fp=='FY' that ends within calendar y
    * Prefers '10-K' over '10-K/A'; picks latest end-date among duplicate
    """
    for tag in tags:
        unit_dict = facts.get("facts", {}).get("us-gaap", {}).get(tag, {}
        for unit, items in unit_dict.items():
            best = best_10k_item(items, fy)
            if best:
                return best["val"], unit

        # ---------- fallback: match by date span -----------------
        yr_start, yr_end = dt.date(fy, 1, 1), dt.date(fy, 12, 31)
        for unit, items in unit_dict.items():
            fy_items = [
                it for it in items
                if it.get("fp") == "FY"
                and "end" in it
                and yr_start <= dt.date.fromisoformat(it["end"]) <= yr_en
            ]
            if fy_items:
                best = max(fy_items, key=lambda d: d["end"])
                return best["val"], unit
    return None

# ──────────────────────────────────────────────────────────────────────
# CSV ENRICHMENT
# ──────────────────────────────────────────────────────────────────────
def enrich(csv_path: Path = INPUT_FILE_GROUND_TRUTH) -> None:
    """
    Populate 'answer' and 'unit' columns in the benchmark CSV, in-place.

    * Ensures columns have correct dtypes (float64, string).
    * Pulls CompanyFacts for each unique ticker (cached).
    * Writes the updated CSV back to `csv_path`.
    """
    print(csv_path)
    df = pd.read_csv(csv_path)

    # ensure dtype compatibility before we start writing floats / strings
    df["answer"] = df.get("answer", pd.Series(index=df.index, dtype="floa
    df["unit"]   = df.get("unit",   pd.Series(index=df.index, dtype="stri

    # cache SEC JSON once per ticker
    facts_cache = {tkr: sec_companyfacts(CIK_LOOKUP[tkr])
                   for tkr in df["ticker"].unique()}

    for idx, row in df.iterrows():
```

```
        tags = GAAP_MAP.get(row["metric"])
        if not tags:
            continue
        res = fy_value(facts_cache[row["ticker"]], tags, int(row["period"
        if res:
            val, unit = res
            df.at[idx, "answer"] = val
            df.at[idx, "unit"]   = unit

    df.to_csv(OUT_FILE_GROUND_TRUTH, index=False)
    print(f"✅ wrote {OUT_FILE_GROUND_TRUTH.resolve()}")

# ──────────────────────────────────────────────────────────────
# NUMERIC EXTRACTION + LLM HELPERS
# ──────────────────────────────────────────────────────────────
def looks_like_idk(text: str) -> bool:
    """Heuristic: does the draft answer contain an 'I don't know' disclai
    return any(re.search(pat, text, re.I) for pat in IDK_PATTERNS)

def parse_numeric(text: str) -> float | None:
    """
    Extract first numeric token + magnitude unit, return value in raw USD

    * Recognises trillion / billion / million / thousand suffixes.
    * Returns None if pattern or unit missing.
    """
    match = num_re.search(text.replace("$", ""))
    if not match:
        return None

    whole = match.group("int").replace(",", "").replace(" ", "")
    frac  = match.group("frac") or ""
    sign  = -1 if match.group("sign") == "-" else 1
    val   = float(f"{whole}.{frac}") if frac else float(whole)
    unit  = (match.group("unit") or "").lower()

    mult  = UNIT_MULT.get(unit, None)
    if mult is None:
        return None                       # unknown unit string
    return sign * val * mult

# ---------- helpers -----------------------------------
def generator_llm(q: str) -> str:
    """Call `ask_openai` with zero-temperature to produce a draft answer.
    return ask_openai(
        messages=[{"role": "user", "content": q}]
    )

def referee_llm_det(q: str, draft: str, lo: float, hi: float) -> bool:
    """
    Deterministic validator for numeric queries.

    Workflow
    --------
    1. `looks_like_idk` → 'defer'
    2. `parse_numeric` → 'defer' on failure
    3. Accept if `lo <= value <= hi`, else 'reject'
    """
    if looks_like_idk(draft):
        return "defer"             # new state
```

```
    val = parse_numeric(draft)
    #print(f"[REFEREE] Q='{q[:60]}…'  draft='{draft[:60]}…'  parsed_val={
    if val is None:
        return "defer"             # couldn't extract number
    return "accept" if lo <= val <= hi else "reject"

def judge_external(row, reason):
    """
    Simulated human fallback (External Judge).

    * Always returns authoritative `row.answer`.
    * Adds 60 s latency & 1.0 human_min.
    * `reason` informs provenance tag.
    """
    answer  = row.answer      # authoritative value
    latency = 60              # seconds of expert lookup (simulated)
    provenance = f"fallback:{reason}"
    return answer, 1.0, provenance     # value, human_min, tag

def write_memory(query_hash, answer):
    """
    Persist an accepted answer to precedent store (stub in toy demo).
    """
    # stub for future precedent store
    pass

# ──────────────────────────────────────────────────────────────────────
# KPI + PLOTTING
# ──────────────────────────────────────────────────────────────────────
def compute_kpi(ledger_path: str, storage_opts=None) -> dict:
    """
    Load a JSONL ledger and compute acceptance / cost metrics.

    Returns
    -------
    dict  keys include:
        accept_rate, reject_rate, defer_rate, coverage_rate,
        avg_latency_s, total_human_min, total_cost_$
    """

    df = pd.read_json(ledger_path, lines=True, storage_options=storage_op

    # pick the latest state column: state, state_p2, state_p3 ...
    state_cols = sorted([c for c in df.columns if re.match(r"state(_p\d+)
    state_col  = state_cols[-1]

    N  = len(df)
    counts = df[state_col].value_counts()
    accept = (df[state_col] == "accept").sum()
    reject = (df[state_col] == "reject").sum()
    defer  = (df[state_col] == "defer").sum()
    unres  = (df[state_col] == "unresolved").sum() if "unresolved" in df[

    # monetise
    df["dollars"] = (
          df[state_col].map(MODEL_COST).fillna(0)
        + df["human_min"] * MIN_WAGE
    )

    return {
```

```
        "ledger"          : ledger_path,
        "state_column"    : state_col,
        "total_queries"   : N,
        "accept_rate"     : accept / N,
        "reject_rate"     : reject / N,
        "defer_rate"      : defer  / N,
        "unresolved_rate" : unres  / N,
        "coverage_rate"   : (accept + reject) / N,
        "avg_latency_s"   : df.latency_s.mean(),
        "total_human_min" : df.human_min.sum(),
        "total_cost_$"    : df.dollars.sum(),
    }

def plot_comparison(kpi1: dict, kpi2: dict, out_dir: Path | None = None):
    """
    Side-by-side bar charts:

    * Chart 1 — accept / reject / defer share, coloured consistently.
    * Chart 2 — total \$ cost per pass.

    Saves PNGs to `out_dir` when provided (README-ready).
    """
    label1, label2 = "Pass 1", "Pass 2"      # or kpi1["ledger"].stem, …

    # ── chart 1  (classification mix) ──────────────────────────────
    cats  = ["accept_rate", "reject_rate", "defer_rate"]
    y1    = [kpi1[c] for c in cats]
    y2    = [kpi2[c] for c in cats]
    x     = range(len(cats))
    width = 0.35

    fig, ax = plt.subplots(figsize=(6, 3), constrained_layout=True)
    ax.bar([xi - width/2 for xi in x], y1, width,
           label=label1, color=COLOR_PASS1)
    ax.bar([xi + width/2 for xi in x], y2, width,
           label=label2, color=COLOR_PASS2)

    ax.set_xticks(x)
    ax.set_xticklabels([c.replace("_rate", "") for c in cats])
    ax.set_ylim(0, 1)
    ax.set_ylabel("fraction")
    ax.set_title("Classifications per pass")
    ax.legend(loc="upper center", bbox_to_anchor=(0.5, -0.18),
              ncol=2, frameon=False)

    if out_dir:
        fig.savefig(out_dir / "kpi_bar.png", dpi=120, bbox_inches="tight"
    plt.show()

    # ── chart 2  (total $ cost) ────────────────────────────────────
    fig2, ax2 = plt.subplots(figsize=(4, 3), constrained_layout=True)
    ax2.bar(0, kpi1["total_cost_$"], color=COLOR_PASS1, label=label1)
    ax2.bar(1, kpi2["total_cost_$"], color=COLOR_PASS2, label=label2)

    ax2.set_xticks([0, 1])
    ax2.set_xticklabels([label1, label2])
    ax2.set_ylabel("$ total cost")
    ax2.set_title("End-to-end cost")
    ax2.legend(loc="upper center", bbox_to_anchor=(0.5, -0.15),
               ncol=2, frameon=False)
```

```
    if out_dir:
        fig2.savefig(out_dir / "cost_bar.png", dpi=120, bbox_inches="tigh
    plt.show()

# ── Change in cost / accepted query ──────────────────────────────
def cost_per_accept(kpi: dict) -> float | None:
    """Return $/accept or None if there were zero accepts."""
    n_acc = int(round(kpi["accept_rate"] * kpi["total_queries"]))
    return kpi["total_cost_$"] / n_acc if n_acc else None

def pretty_print_kpi(k: dict) -> None:
    """Readable console dump of key KPI fields + monetised cost."""
    print("\n== KPI Summary ==")
    for key in [
        "total_queries", "accept_rate", "reject_rate", "defer_rate",
        "unresolved_rate", "coverage_rate", "avg_latency_s",
        "total_human_min",
    ]:
        val = k[key]
        print(f"{key:20}: {val:.3f}" if isinstance(val, float) else
              f"{key:20}: {val}")
    print(f"\nEstimated total $ cost: ${k['total_cost_$']:.2f}")
```

In [4]:

```
"""
fill_answers_from_sec.py
Populate the 'answer' column of the 100-query benchmark CSV
using SEC Company Facts data (10-K).  Tolerates Jupyter's -f flag.
"""

ap = argparse.ArgumentParser()
ap.add_argument("--csv", default=str(INPUT_FILE_GROUND_TRUTH),
                help="Input benchmark CSV (local path).")
args, _rest = ap.parse_known_args()
enrich(Path(args.csv))
```

```
benchmark_queries_100_FY2021_FY2023.csv
✅ wrote /home/ec2-user/SageMaker/notebooks/outputs/ground_truth.csv
```

In [5]:

```
# ╔═══════════════════════════════════════════════════════════════════════╗
# ║ PASS-1  ·  Deterministic "validator" loop                             ║
# ╠═══════════════════════════════════════════════════════════════════════╣
# ║ • For each benchmark query we:                                        ║
# ║     1. Ask the generator LLM for a draft numeric answer.              ║
# ║     2. Parse that draft deterministically (`referee_llm_det`).        ║
# ║     3. Accept if it falls within ±5 % of the ground-truth value       ║
# ║        (bounds = answer·LOWER_TOL_FACTOR .. answer·UPPER_TOL_FACTOR)  ║
# ║        – the validator never sees the exact ground-truth.             ║
# ║     4. Reject → call simulated External Judge (adds human cost).      ║
# ║     5. Defer → leave unanswered this pass (no judge, no memory).      ║
# ║ • Each iteration is timed and a JSON-serialisable record is pushed    ║
# ║   to `ledger_pass1`.                                                  ║
# ║ • At the end we write the ledger to  ./outputs/ledger_pass1_<id>.     ║
# ╚═══════════════════════════════════════════════════════════════════════╝

# ---------- load ground truth ------------------------
df_gt = pd.read_csv(GT_PATH)

for _, row in df_gt.iterrows():
    q, lo, hi = row.query, row.answer * LOWER_TOL_FACTOR, row.answer * UP
```

```
    t0 = time.time()
    draft = generator_llm(q)
    state = referee_llm_det(q, draft, lo, hi)

    if state == "accept":
        answer, human_min, prov = draft, 0.0, "generator"

    elif state == "reject":
        answer, human_min, prov = judge_external(row, "reject")

    else:  # state == "defer"
        answer, human_min, prov = None, 0.0, "deferred"
        # no judge call, no memory write

    # only write memory when we actually have an answer
    if answer is not None:
        write_memory(hash(q), answer)

    ledger_pass1.append(dict(
        query_id=int(row.id),
        draft=draft,
        state=state,
        answer=answer,
        human_min=human_min,
        latency_s=round(time.time()-t0,3),
    ))

dest_path = OUT_DIR / f"ledger_pass1_{RUN_ID}.jsonl"

with dest_path.open("w") as f:
    for rec in ledger_pass1:
        f.write(json.dumps(rec) + "\n")

print("PASS-1 complete; ledger saved to:", dest_path)
```

```
PASS-1 complete; ledger saved to: /home/ec2-user/SageMaker/notebooks/outpu
ts/ledger_pass1_3a2b9ef6.jsonl
```

In [6]:

```
# ╔═══════════════════════════════════════════════════════════════════╗
# ║ KPI REPORT · Pass 1                                               ║
# ╚═══════════════════════════════════════════════════════════════════╝
# ║ • `compute_kpi()` loads the JSONL ledger we just wrote and        ║
# ║   returns a dict of headline metrics (accept/reject/defer rates,  ║
# ║   average latency, human-minutes, monetised cost, …).             ║
# ║ • `pretty_print_kpi()` renders that dict as a human-friendly      ║
# ║   summary block in the notebook output.                           ║
# ║                                                                   ║
# ║   Input  : PASS1_OUT   → ./outputs/ledger_pass1_<RUN_ID>.jsonl    ║
# ║   Output : nicely-formatted KPI table in the cell's stdout.       ║
# ╚═══════════════════════════════════════════════════════════════════╝

kpi1 = compute_kpi(PASS1_OUT)
pretty_print_kpi(kpi1)
```

```
== KPI Summary ==
total_queries       : 100
accept_rate         : 0.660
reject_rate         : 0.200
defer_rate          : 0.140
unresolved_rate     : 0.000
coverage_rate       : 0.860
avg_latency_s       : 0.741
total_human_min     : 20

Estimated total $ cost: $10.10
```

In [7]:

```python
# ╔═══════════════════════════════════════════════════════════════════════╗
# ║ PASS-2 · "Defer-fix" sweep                                            ║
# ╠═══════════════════════════════════════════════════════════════════════╣
# ║ Goal                                                                  ║
# ║ ──────────────────────────────────────────────────────────────────────║
# ║ • Re-load the Pass-1 ledger.                                          ║
# ║ • Any query that was *accepted* or *rejected* in Pass-1 is            ║
# ║   copied through unchanged (state_p2 = original state).               ║
# ║ • Any query that was *deferred* is now sent to the simulated          ║
# ║   External Judge C:                                                   ║
# ║       – pull authoritative value from ground_truth CSV                ║
# ║       – mark the new verdict as "accept" (always in-range)            ║
# ║       – add 1.0 human_min   (full expert minute)                      ║
# ║       – add 0.25 s latency  (lookup delay)                            ║
# ║       – provenance tag  =  'fallback:defer_fix'                       ║
# ║       – write answer to precedent store via `write_memory()`          ║
# ║ • Serialise the resulting list to  ./outputs/ledger_pass2_<id>.       ║
# ║ • Pass-2 therefore eliminates all defers and yields 100 %             ║
# ║   coverage before we compute KPI_2 / plots.                           ║
# ╚═══════════════════════════════════════════════════════════════════════╝

ledger_pass1 = pd.read_json(PASS1_OUT, lines=True)
gt      = pd.read_csv(GT_PATH).set_index("id")

for rec in ledger_pass1.to_dict("records"):
    if rec["state"] != "defer":
        rec["state_p2"] = rec["state"]     # keep old verdict as the pass
        ledger_pass2.append(rec)                 # accept / reject unchan
        continue

    # --- Judge C supplies authoritative value ---
    val = gt.loc[rec["query_id"], "answer"]

    lo, hi = val*LOWER_TOL_FACTOR, val*UPPER_TOL_FACTOR
    state2 = "accept" if lo <= val <= hi else "reject"   # should be acce

    rec.update({
        "state_p2": state2,
        "answer": val,
        "human_min": 1.0,                  # simulated deeper lookup
        "provenance": "fallback:defer_fix",
        "extra_latency_s": 0.25,
    })
    write_memory(hash(rec["draft"]), val)
    ledger_pass2.append(rec)

# dump Pass 2 ledger
dest_path = OUT_DIR / f"ledger_pass2_{RUN_ID}.jsonl"
```

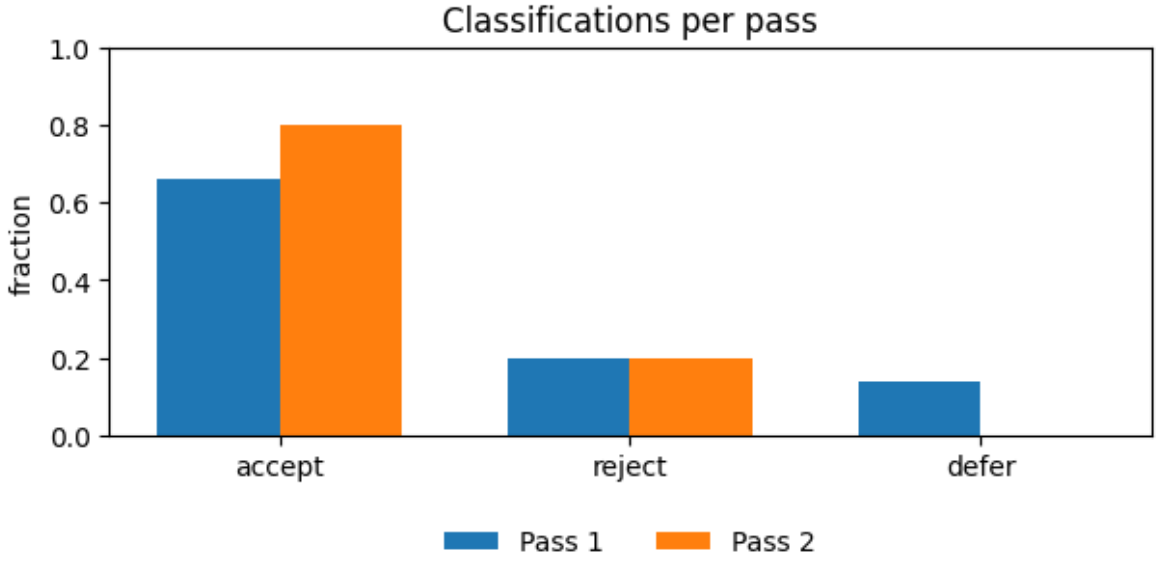
```
with dest_path.open("w") as f:
    for rec in ledger_pass2:
        f.write(json.dumps(rec) + "\n")

print("PASS-2 complete; ledger saved to:", dest_path)
```

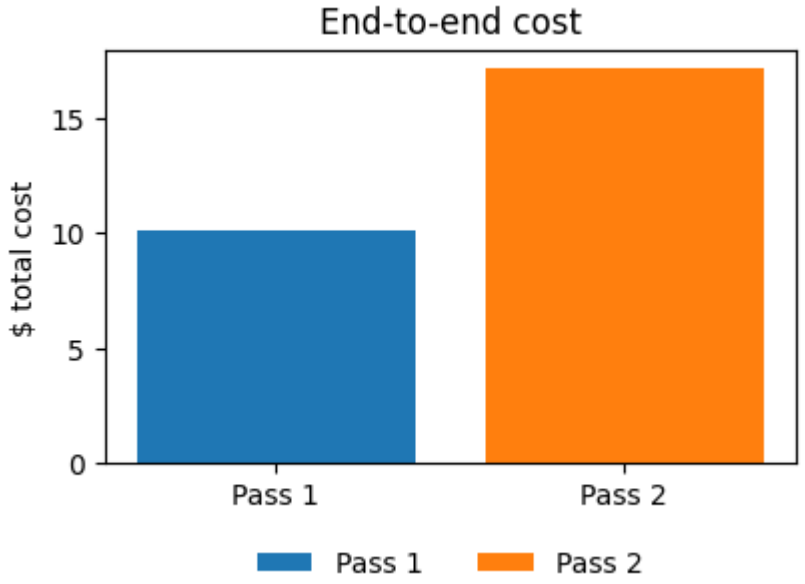
```
PASS-2 complete; ledger saved to: /home/ec2-user/SageMaker/notebooks/outpu
ts/ledger_pass2_3a2b9ef6.jsonl
```

In [8]:
```
# ╔═══════════════════════════════════════════════════════════════════╗
# ║ KPI REPORT · Pass 2 (after defer-fix)                             ║
# ╠═══════════════════════════════════════════════════════════════════╣
# ║ • `compute_kpi()` loads the Pass-2 ledger we just wrote and       ║
# ║   recalculates all headline metrics.                              ║
# ║ • `pretty_print_kpi()` prints the same nicely-formatted summary   ║
# ║   so we can compare directly with the Pass-1 table above.         ║
# ║                                                                   ║
# ║   Input  : PASS2_OUT → ./outputs/ledger_pass2_<RUN_ID>.jsonl      ║
# ║   Output : KPI table for Pass 2 in cell stdout.                   ║
# ╚═══════════════════════════════════════════════════════════════════╝

kpi2 = compute_kpi(PASS2_OUT)
pretty_print_kpi(kpi2)
```

```
== KPI Summary ==
total_queries       : 100
accept_rate         : 0.800
reject_rate         : 0.200
defer_rate          : 0.000
unresolved_rate     : 0.000
coverage_rate       : 1.000
avg_latency_s       : 0.741
total_human_min     : 34

Estimated total $ cost: $17.10
```

In [9]:
```
# ╔═══════════════════════════════════════════════════════════════════╗
# ║ VISUAL SUMMARY · Pass-1  vs  Pass-2                               ║
# ╠═══════════════════════════════════════════════════════════════════╣
# ║ • `plot_comparison()` draws two side-by-side figures:             ║
# ║       1.  Bar chart of accept / reject / defer share             ║
# ║           (colours stay consistent across passes).                ║
# ║       2.  Bar chart of total \$ cost for each pass.               ║
# ║ • PNGs are saved to  OUT_DIR / {kpi_bar.png, cost_bar.png}        ║
# ║   so they can be embedded in the README, plus rendered inline.    ║
# ╚═══════════════════════════════════════════════════════════════════╝

plot_comparison(kpi1, kpi2, out_dir=OUT_DIR)
```


Classifications per pass
1.0
0.8
0.6
0.4
0.2
0.0
fraction
accept
reject
defer
Pass 1
Pass 2


End-to-end cost
15
10
5
0
$ total cost
Pass 1
Pass 2
Pass 1
Pass 2

In [ ]: