BIOMEDICAL & HEALTH

Choosing Your First Biomedical Engineering Project

Turn a healthcare problem into a project you can actually build and validate — without university lab access, patient contact, or a clinical background.

SKILL LEVEL: BEGINNER–INTERMEDIATE **BUILD TIME:** 1–3 WEEKS TO A VALIDATED PROJECT PLAN

EST. COST: $0–40 (DEPENDS ON PATHWAY CHOSEN)

> Before you start: you don't need a lab, a hospital connection, or a medical degree. Real biomedical engineering work happens on public datasets, low-cost sensors, and careful literature review just as often as it happens in a wet lab.

01 Objective

The most common way students stall on a biomedical project isn't lack of ability — it's picking a problem that quietly requires a hospital partnership, IRB approval, or lab equipment they don't have access to, and discovering that six weeks in. By the end of this blueprint, you'll know how to identify a healthcare problem worth working on, choose a pathway (hardware, software, or literature-based research) that matches what you can actually access, and validate that your project idea is realistic before you commit weeks to it.

02 Prerequisites

- Curiosity about a health or healthcare-access problem — personal, family, or community observation is a legitimate starting point
- Comfort with basic spreadsheets or one programming language, depending on the pathway you choose in Section 5
- No prior biology or clinical coursework required — most beginner-accessible projects are learnable from public resources as you go

03 Recommended Toolkit

TOOL / RESOURCE	PURPOSE	NOTES
PhysioNet	Free physiological signal datasets (ECG, EEG, etc.)	Free — physionet.org, widely used in published research
Kaggle Datasets (health category)	Cleaned medical and health datasets ready for analysis	Free — kaggle.com
PubMed / Google Scholar	Published research to check what's already known	Free — essential before finalizing any project idea
Arduino Uno + pulse/temperature sensor kit	Low-cost hardware prototyping (if hardware pathway chosen)	$15–30 total, reuses the same skills as BP-001
Python with pandas / NumPy / SciPy	Signal processing and data analysis	Free — the standard toolkit for biomedical data work
A one-page ethics checklist (Section 4)	Confirms your project doesn't require formal review	Free — use before starting any data collection involving people

04 Tools Required

- A computer with internet access for datasets and literature search
- Depending on pathway: Python, or basic hardware tools (no soldering required for most beginner builds)

> ETHICS BEFORE ANYTHING ELSE
> The moment your project involves collecting data from or about other people — even something as simple as heart rate measurements from classmates — you may need informed consent and, for school competitions, guidance from a teacher or mentor on your institution's human-subjects policy. This isn't optional paperwork; it's the same standard real biomedical research follows. When in doubt, use public datasets instead of collecting your own — it sidesteps this entirely and is a completely legitimate research method.

05 Choosing Your Pathway

Every accessible biomedical project falls into one of three pathways. Picking the one that matches what you can actually access — rather than the one that sounds most impressive — is what determines whether you finish the project.

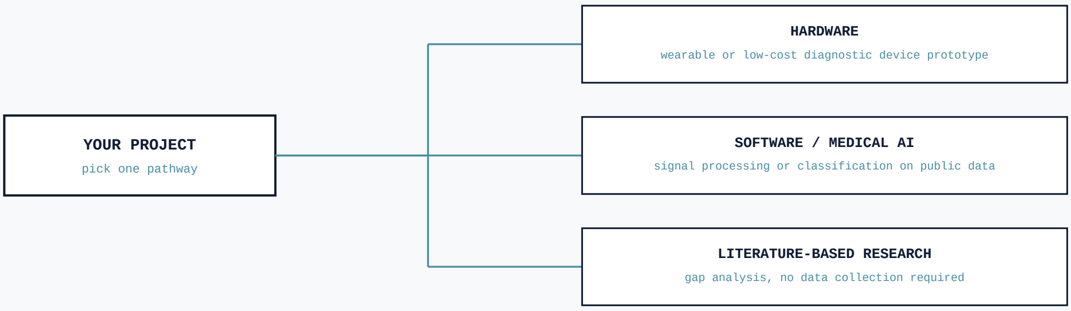

FIG. 1 — THREE PATHWAYS INTO BIOMEDICAL ENGINEERING, EACH WITH DIFFERENT ACCESS REQUIREMENTS

PATHWAY	WHAT IT LOOKS LIKE	ACCESS NEEDED
Hardware	A low-cost pulse sensor, posture monitor, or fall-detection prototype	Basic electronics (same as BP-001), no lab required
Software / Medical AI	A model that classifies ECG signals or predicts a health outcome from public data	Just a computer — no patient data collection needed
Literature-Based Research	A structured review identifying an unanswered question in published research	Only internet access — no equipment, no data collection

06 Step-by-Step Build

1. **Start from a real problem, not a technology.** "I want to use AI" isn't a project. "Diabetic patients in rural areas often can't get regular checkups" is a problem you can design around.
2. **Search the existing literature before designing anything.** Spend a real afternoon on PubMed or Google Scholar. If your exact idea already has a well-established solution, look for what's still unsolved within it — that gap is your actual project.
3. **Choose your pathway using Section 5.** Match the pathway to what you can access, not what sounds most advanced on a poster.
4. **Run the ethics checklist before collecting anything.** If your project needs data from people, talk to a teacher or mentor now, not after you've already started collecting.
5. **Build the smallest working version first.** A prototype that measures one signal reliably beats an ambitious device that measures five signals badly.
6. **Validate against something known.** Compare your sensor readings to a reference device, or your model's predictions to labeled data you didn't train on — validation is what turns a demo into evidence.
7. **Document limitations honestly.** Every low-cost or beginner-accessible project has real limitations compared to clinical-grade equipment — naming them accurately is a sign of rigor, not weakness.

07 Data Walkthrough

Here's what an early validation step looks like for the software/medical AI pathway — loading a public physiological signal dataset and checking basic signal quality before attempting any classification.

```
import wfdb
import numpy as np

# Load a sample ECG record from PhysioNet (e.g., MIT-BIH Arrhythmia Database)
record = wfdb.rdrecord("100", pn_dir="mitdb")
signal = record.p_signal[:, 0]  # first channel

# Basic sanity checks before any modeling
print("Sampling rate:", record.fs, "Hz")
print("Duration:", len(signal) / record.fs, "seconds")
print("Missing values:", np.isnan(signal).sum())
print("Signal range:", signal.min(), "to", signal.max())
```

```
# A real signal should not be flat or full of extreme outliers
if signal.std() < 0.01:
    print("Warning: signal has almost no variation — check the recording.")
```

This kind of sanity check — confirming sampling rate, missing values, and realistic signal range — belongs before any classification model, not after.

08 Common Mistakes

MISTAKE	WHY IT HURTS	FIX
Designing around a hospital partnership that never materializes	Access to clinical settings is unpredictable and often falls through	Default to public datasets or literature-based research unless access is already confirmed in writing
Skipping the literature search	Reinventing an already-solved problem wastes weeks and reads poorly to judges	Spend a dedicated session on PubMed before finalizing scope
Collecting personal health data without consent	This is an ethics violation regardless of intent, even in an informal setting	Use the ethics checklist in Section 4 before collecting anything from other people
No comparison or validation baseline	A sensor reading or model prediction means little without something to compare it to	Always validate against a reference device, labeled dataset, or established benchmark
Overstating clinical relevance	Claiming a prototype is "ready for real patients" undermines credibility with any knowledgeable reviewer	Frame the project as a proof of concept, and state clearly what further validation it would need

09 Where This Goes Next

FROM PROJECT IDEA TO A VALIDATED PROPOSAL

Once you've chosen a pathway and confirmed it's realistic, the next step is turning it into a structured project plan with a clear research question and method — exactly what a formal research write-up requires. If your project leans toward the software pathway, pair this blueprint with **SA-001 (Building Your First Real AI Project)** for the build workflow, or with **ES-001 (Designing Your First Environmental Research Project)** if it involves field data collection with wearables. See the Research & Scientific Writing series for how to frame this formally as a research paper or competition proposal.