1. Consider a mobile application designed to monitor physical activity, which senses accelerometer data and uploads it to a central server through the 4G network. The upload operation is power hungry and consumes **60 mW** of power when active and **1 mW** when idle. **1 point**

   Suppose there is a particular user who uses the application to track calorie burn during exercise. Every day, the user wears a Nike shoe with a piezo-electric device attached to it and goes for a one-hour run. The device generates electricity from each step at the rate of **7 mJ** per step. The user takes approximately **8000 steps** on every one-hour run. The user wants the exercise app to be energy neutral. "Energy neutrality" means that if the mobile battery level is B_0 when the application *starts* executing, then the battery level is still B_0 after the application *finishes* executing.

   Does "energy neutral" imply that the app does not consume any battery power?

   - (•) false
   - ( ) true

2. Consider a mobile application designed to monitor physical activity, which senses accelerometer data and uploads it to a central server through the 4G network. The upload operation is power hungry and consumes **60 mW** of power when active and **1 mW** when idle. **1 point**

   Suppose there is a particular user who uses the application to track calorie burn during exercise. Every day, the user wears a Nike shoe with a piezo-electric device attached to it and goes for a one-hour run. The device generates electricity from each step at the rate of **7 mJ** per step. The user takes approximately **8000 steps** on every one-hour run. The user wants the exercise app to be energy neutral. "Energy neutrality" means that if the mobile battery level is B_0 when the application *starts* executing, then the battery level is still B_0 after the application *finishes* executing.

   What should be the duty cycle of the 4G radio so that the mobile application is energy neutral for 1 hour of app operation?

   100

3. Consider a mobile application designed to monitor physical activity, which senses accelerometer data and uploads it to a central server through the 4G network. The upload operation is power hungry and consumes **60 mW** of power when active and **1 mW** when idle. **1 point**

   Suppose there is a particular user who uses the application to track calorie burn during exercise. Every day, the user wears a Nike shoe with a piezo-electric device attached to it and goes for a one-hour run. The device generates electricity from each step at the rate of **7 mJ** per step. The user takes approximately **8000 steps** on every one-hour run. The user wants the exercise app to be energy neutral. "Energy neutrality" means that if the mobile battery level is B_0 when the application *starts* executing, then the battery level is still B_0 after the application *finishes* executing.

   Does the ability for energy neutral operation depend on the initial battery level?

   - ( ) No, the ability for energy neutral operation does not depend on anything.
   - ( ) Yes, but it does not depend on the application.
   - ( ) Maybe, but it depends solely on the initial battery level.
   - (•) Maybe, but it depends on both battery level and power profile of the application.

4. Can the results of a single macro-benchmark be achieved by carefully combining multiple micro-benchmarks? **1 point**

   - ( ) true
   - (•) false

5. What are some of the problems with a model based power measurement software tool? *Select all that apply.* **1 point**

   - [x] The models tend to provide a different granularity of data than sensors and introduce errors in the process.
   - [x] The software tool measuring power can influence the power measurements.
   - [x] The models are not accurate and only work for a small set of experiments.
   - [x] The sensors are not accurate enough to guarantee good accuracy for the models.

6. Which statement *most accurately* describes how the number of wakelocks relates to power? **1 point**

   - ( ) Lower number of wakelocks result in lower average power
   - (•) Lower number of wakelocks result in lower instantaneous power
   - ( ) Lower number of wakelocks result in higher instantaneous power
   - ( ) Lower number of wakelocks result in higher average power

7. Suppose there is a mobile application that can run in two modes: Lazy or Eager. In Lazy Mode, the execution time is **4 seconds**. In Eager Mode, the app utilizes a faster timer resolution for its computations, so the execution time in Eager Mode is **3 seconds** (i.e., Eager Mode execution time is **75%** of Lazy Mode execution time). 1 point

After finishing computation, the app sends some data to the cloud, regardless of the mode it's in. The data size sent to the cloud is **50 MB**. The bandwidth of communication is **5 MBps** for WiFi and **4 MBps** for 4G. Assume that the communication radio is idle during the computation time.

Assume that the communication radio for WiFi has a power consumption of **60 mW** when active and **1 mW** when idle. Similarly, assume that the communication radio for 4G has a power consumption of **80 mW** when active and **2 mW** when idle. The Idle Power of the CPU is **0.5 mW**, whereas the Active Power of the CPU is **1 mW** per unit utilization. Assume that the power consumption of the CPU is a linear function of its utilization. In other words: P = (Idle Power) + (Utilization)*(Power per unit Utilization).

A configuration of the mobile app involves choosing a timer resolution (Lazy or Eager) and choosing a type of radio (WiFi or 4G). For example, faster timer resolution (Eager) and 4G network is a configuration, while slower resolution (Lazy) and WiFi is another. There are four possible configurations in all.

Which configuration is the *most* energy efficient?

- ○ Eager 4G
- ○ Lazy 4G
- ◉ Eager Wifi
- ○ Lazy WiFi

8. Suppose there is a mobile application that can run in two modes: Lazy or Eager. In Lazy Mode, the execution time is **4 seconds**. In Eager Mode, the app utilizes a faster timer resolution for its computations, so the execution time in Eager Mode is **3 seconds** (i.e., Eager Mode execution time is **75%** of Lazy Mode execution time). 1 point

After finishing computation, the app sends some data to the cloud, regardless of the mode it's in. The data size sent to the cloud is **50 MB**. The bandwidth of communication is **5 MBps** for WiFi and **4 MBps** for 4G. Assume that the communication radio is idle during the computation time.

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A configuration of the mobile app involves choosing a timer resolution (Lazy or Eager) and choosing a type of radio (WiFi or 4G). For example, faster timer resolution (Eager) and 4G network is a configuration, while slower resolution (Lazy) and WiFi is another. There are four possible configurations in all.

Which configuration has the *shortest* execution time?

- ◉ Eager Wifi
- ○ Lazy 4G
- ○ Lazy WiFi
- ○ Eager 4G

9. Suppose there is a mobile application that can run in two modes: Lazy or Eager. In Lazy Mode, the execution time is **4 seconds**. In Eager Mode, the app utilizes a faster timer resolution for its computations, so the execution time in Eager Mode is **3 seconds** (i.e., Eager Mode execution time is **75%** of Lazy Mode execution time). 1 point

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A configuration of the mobile app involves choosing a timer resolution (Lazy or Eager) and choosing a type of radio (WiFi or 4G). For example, faster timer resolution (Eager) and 4G network is a configuration, while slower resolution (Lazy) and WiFi is another. There are four possible configurations in all.

Which configuration has the *highest* maximum power consumption?

- ○ Eager Wifi
- ◉ Lazy 4G
- ○ Lazy WiFi
- ○ Eager 4G

10. Suppose there is a mobile application that can run in two modes: Lazy or Eager. In Lazy Mode, the execution time is **4 seconds**. In Eager Mode, the app utilizes a faster timer resolution for its computations, so the execution time in Eager Mode is **3 seconds** (i.e., Eager Mode execution time is **75%** of Lazy Mode execution time). 1 point

After finishing computation, the app sends some data to the cloud, regardless of the mode it's in. The data size sent to the cloud is **50 MB**. The bandwidth of communication is **5 MBps** for WiFi and **4 MBps** for 4G. Assume that the communication radio is idle during the computation time.

Assume that the communication radio for WiFi has a power consumption of **60 mW** when active and **1 mW** when idle. Similarly, assume that the communication radio for 4G has a power consumption of **80 mW** when active and **2 mW** when idle. The Idle Power of the CPU is **0.5 mW**, whereas the Active Power of the CPU is **1 mW** per unit utilization. Assume that the power consumption of the CPU is a linear function of its utilization. In other words: P = (Idle Power) + (Utilization)*(Power per unit Utilization) words: P = (Idle Power) + (Utilization) (Power per unit Utilization).

A configuration of the mobile app involves choosing a timer resolution (Lazy or Eager) and choosing a type of radio (WiFi or 4G). For example, faster timer resolution (Eager) and 4G network is a configuration, while slower resolution (Lazy) and WiFi is another. There are four possible configurations in all.

Which configuration has the *highest* average power consumption?

- ( ) Lazy 4G
- (•) Eager 4G
- ( ) Lazy WiFi
- ( ) Eager Wifi