Exercise 0630 for "Semiconductors"

Problem setting:	16/06/2021	出題	2021 年 6 月 16 日
Solution submission deadline:	30/06/2021	解答提出期限	2021 年 6 月 30 日

General notes / 一般的注意

The text part in the answer should be typed in English or Japanese. I hope you could avoid handwriting but if you have no way to do so, the handwriting should be as clear as possible. The scoring does not depend on the language. It doesn't matter if you are good at grammar, vocabulary, or sentences, but if I cannot catch the meaning, the scoring will get deducted regardless of English or Japanese. The answer sheet should be in small-sized (hopefully less than 1 MB) PDF format, which can be appropriately displayed by Adobe Reader. The file of the answer should be submitted through ITC-LSM.

解答のテキスト部分は極力手書きでないようにお願いします．英語，日本語のどちらでも良く，採点は言語に依存しません．文法や語法，文章の上手下手は問題にしませんが，意味が取れない場合は，英語日本語にかかわらず，減点します．解答は，ファイルサイズのできるだけ小さな (1 MB 以下が目安)，Adobe Reader できちんと表示できる PDF ファイルにまとめ，ITC-LSM を通して提出してください．

0630-1 Solar cell

Consider a silicon solar cell at T=300 K with a reverse saturation current of $I_S = 10^{-10}$ A and an induced short-circuit photocurrent of I_L = 100 mA. Assume the pn junction obeys the Schockley theorem.

(a) Determine $V_{\rm oc}$ (open circuit voltage).

(b) Let $V_{\rm m}$, $I_{\rm m}$, and $P_{\rm m}$ be the volgate, the current and the power at the maximum power point respectively. Find $V_{\rm m}$, $I_{\rm m}$, and $P_{\rm m}$.

(c) How many cells, operating at the maximum output power, must be connected in series to produce an output voltage of at least 10 V?

(d) How many of the 10 V cells in part (c) must be connected in parallel to produce an output power of at least 5.2 W?

(e) Considering the results of part (d), what must be the load resistance connected across the solar cell system to produce the maximum output power?

0630-2 Light emitting diode

In a special LED with a flat surface, consider a point light source in the semiconductor and assume that photons are emitted uniformly in all directions from the point. When one can neglect photon absorption, show that the optical efficiency of the LED is given by

$$\eta_{\rm opt} = \frac{2\bar{n}_2\bar{n}_1}{(\bar{n}_1+\bar{n}_2)^2}(1-\cos\theta_{\rm c}),$$

where $\bar{n}_1$ and $\bar{n}_2$ are the index of refraction parameters for the air and semiconductor, respectively, and θ_c is the critical angle.