

Introduction

This assignment evaluates the approximate indoor lighting levels in Abdul Kader's apartment in Mar Elias, Beirut, Lebanon. The installed lighting arrangement was documented room by room, including rounded ceiling spotlights and downlights, indirect smooth ceiling lighting (also called cove lighting), LED lighting on ceilings or walls (either white or warmer white (yellowish), mirror lighting (also either white or yellowish). Yellowish meaning warmer white, simply. The goal is to estimate the maintained illuminance in lux for each space and compare the result with the typical household values provided (in the course's material).

The calculation follows the lumen method used in the course material, the pictures taken are used to classify the visible lighting sources and visually approximate each room's dimensions.

The apartment lighting circuits are also visibly grouped in Abed's home panelboard, under 'Lights'. The photographed section contains 6x Schneider Electric MCBs, specifically 2x C16 A breakers and 4x C10 A breakers.

Part 1 – Methods and Assumptions

1.1 Lumen Method

In class, illuminance is defined as luminous flux per unit area, where 1 lux = 1 lumen/m². For more than one source type in a room, the maintained illuminance is estimated using:

$$E = \frac{\sum (N \times \Phi \times CU \times LLF)}{A}$$

where E is the maintained illuminance (lux), N is the number of luminaires (or strip length in meters), 'phi' is the source luminous flux, CU is the coefficient of utilization, LLF is the light loss factor, and A is the room area in m².

In the slides, CU values are given being 0.6-0.8 for rooms and 0.3-0.5 for corridors. We used a single LLF of 0.85, which is the midpoint of the range of 0.8-0.9 used in the slides. Lower CU values are used for cove and wall lighting because part of their light is first reflected from room surfaces before reaching the working plane.

Abdul Kader couldn't identify the exact brands of the 3 main lighting types used in his home being: Small Spotlights, Large Downlights, and LED Cove/Strips. We couldn't know their exact 'W' and 'lm' ratings, so we searched the web to know a rough estimate for each of the three types, even though they may not be available on the lebanese market (all details included in the Reference list at the end).

Please note that same luminous flux of 800 lm/m was used for both Cove LED (thick yellowish LED) and Strip LED (white LED), but lower CU for the Cove ones, as the light is indirect and reflects off the walls, and also different CU for the Strip LED depending on location.

Additionally, recessed means rounded spotlights/downlights, providing a yellowish lighting, and that cove lighting summarizes those hidden smooth LED that create a soft environment. (Most of the time yellowish, sometimes white, that's where they're called LED Strips)

1.2 Different Lighting Sources Identified

Observed	What we actually see	Rating used	Usual Location
Small Recessed LED Spotlights	Small rounded yellow spotlights	4.6 W and 410 lm/small spotlight	Bedrooms, entrance, bathrooms, living and dining rooms
Larger Recessed LED Downlights	Same as the small ones yet larger in size	10 W and 800 lm/large downlight	Kitchen, laundry room, balcony
Indirect LED Cove & LED Strips	Smooth yellow lighting around the ceilings & White LED lines on the walls	Approximately 800 lm/m	Ceiling edges (or Coves) and wall lighting
Mirror LED	Lighting emerging from mirrors' borders, in each of the 3 bathrooms	Assumed a 900 lm total for each mirror.	Across 3 mirrors (each in a bathroom)

1.3 Room Dimensions

Room dimensions are approximates, visualized by the naked eyes. The same dimensions are used consistently in all calculations below.

Part 2 - Observed Home Lighting Arrangement

The following pictures show the installed lighting throughout Abed's apartment, used in the calculations. (Please note that there are reflections visible in mirrors, but they are not counted as additional luminaires).



Figure 1 - Abed's Apartment Panelboard, Lights Section

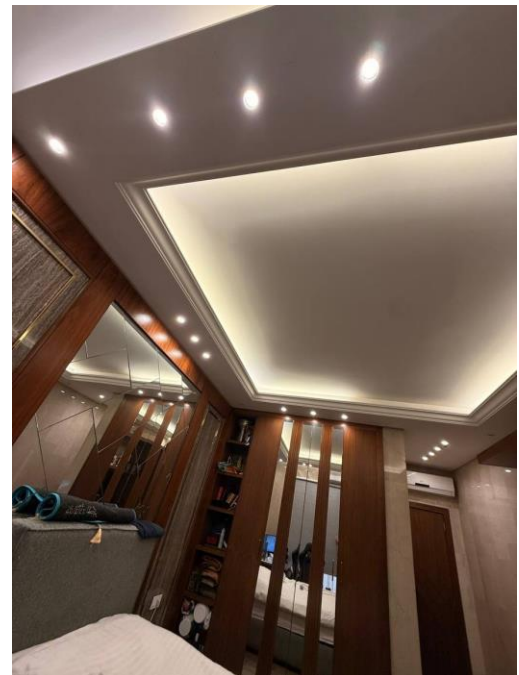


Figure 2 - Bedroom 1 Ceiling



Figure 3 - Corridor Connecting Bedrooms Ceiling



Figure 4 - Bedroom 2 Ceiling



Figure 5 - Master Bedroom Ceiling

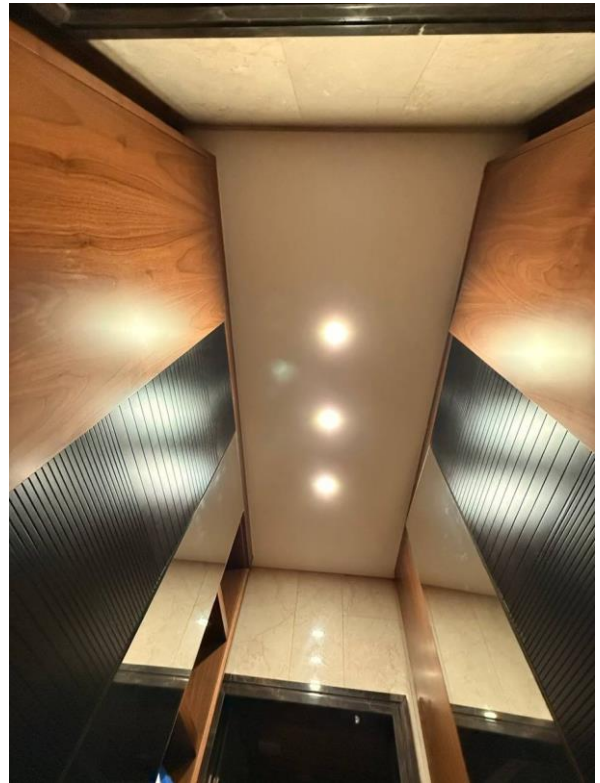


Figure 6 - Master Bedroom's Mini Corridor Ceiling



Figure 7 - Master Bedroom's Toilet Ceiling

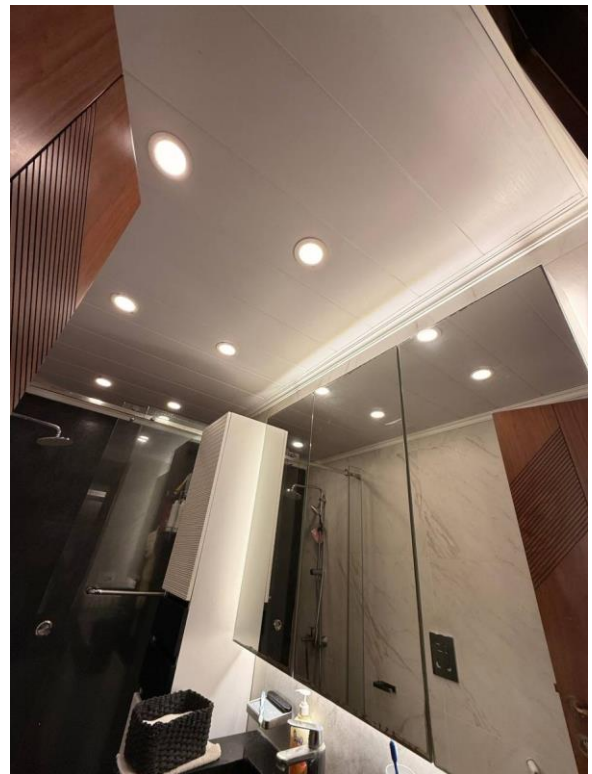


Figure 8 - Main Toilet Ceiling



Figure 9 - Kitchen Corridor Ceiling



Figure 10 - Laundry Room Ceiling



Figure 11 - Kitchen Ceiling



Figure 12 - Dining Room Wall



Figure 13 - Dining Room Ceiling

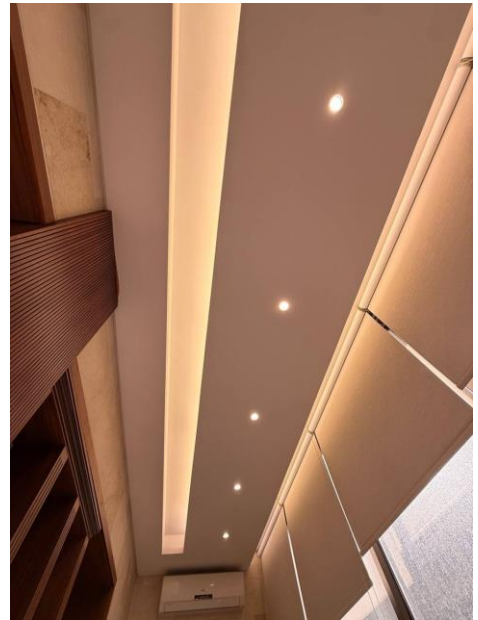


Figure 14 - Windowed Balcony Ceiling



Figure 15 - Guests' Toilet Ceiling & Wall

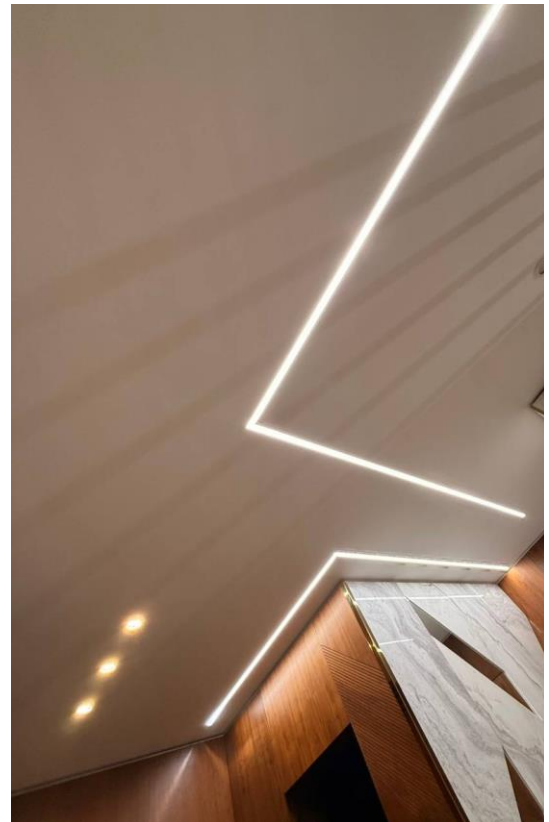


Figure 16 - Entrance Ceiling



Figure 17 - Living Room Ceiling

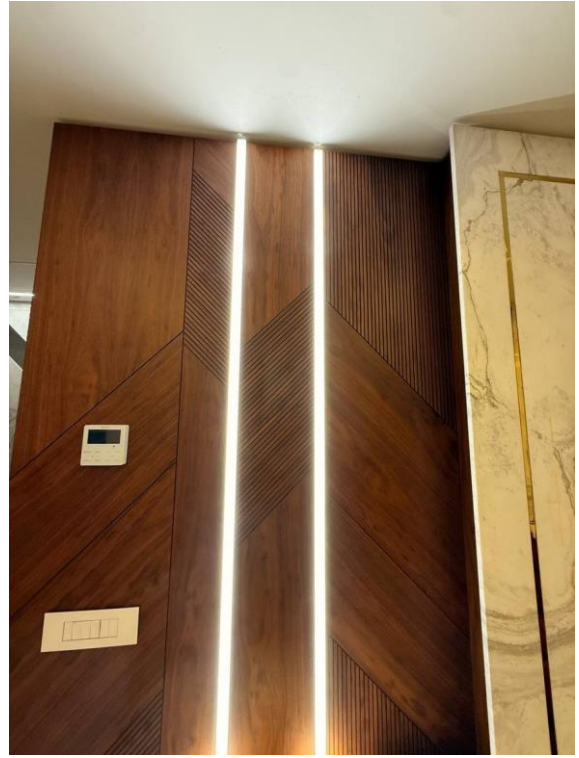


Figure 18 - Living Room Wall



Figure 19 - Balcony Ceiling

Part 3 - Lighting Calculations

The lumen method equation is applied to every space. The calculations below show the calculated illuminance E in lux for every space in the apartment, photographed just above. Also, a summary table containing all results is included at the end.

3.1 Engineering Calculations

$$E = \frac{\sum (N \times \Phi \times CU \times LLF)}{A}$$

for all calculations, $LLF = 0.85$

N = no. of lights
(for LED strips, we use length in 'm')

A = length $\times$ width

Φ = lumens flux

CU = coef. of utilization

- Small rounded spotlights: 410 lm
- Large rounded downlights: 800 lm
- Cove/Strip LED: 800 lm/m
- Each Mirror LED: 900 lm/m (in a bathroom)

note: spotlight $\rightarrow$ small rounded ceiling lights
downlight $\rightarrow$ larger rounded ceiling lights

Figure 2 - Bedroom 1

$A = 4.5m \times 3.2m = 17.1m^2$

$\left\{ \begin{array}{l} 12 \text{ small spotlights} \\ N = 12 \end{array} \right. + \text{around 11m cove LED}$

$\left\{ \begin{array}{l} \Phi = 410lm \\ CU = 0.7 \end{array} \right. \quad \left\{ \begin{array}{l} N = 11m \\ \Phi = 800lm/m \\ CU = 0.45 \text{ (lower CU since indirect)} \end{array} \right.$

$$E = \frac{(12 \times 410 \times 0.7 \times 0.85) + (11 \times 800 \times 0.45 \times 0.85)}{17.1}$$

$$= 368 \text{ lux}$$

Figure 3 - Corridor Connecting Bedrooms

$$\left\{ \begin{array}{l} A = 5.2\text{m} \times 1.25\text{m} = 6.5\text{ m}^2 \\ 6 \text{ ^{small} spotlights + around 5m strip LED} \end{array} \right.$$

$$N = 6$$

$$\phi = 412\text{m}$$

$$CU = 0.4$$

$$N = 5$$

$$\Phi = 800\text{lm/m}$$

$$CU = 0.5$$

$$E = \frac{(6 \times 410 \times 0.4 \times 0.85) + (5 \times 800 \times 0.5 \times 0.85)}{6.5}$$

$$= 390 \text{ lux}$$

Figure 4 - Bedroom 2

$$\left\{ \begin{array}{l} A = 4.8\text{m} \times 3.8\text{m} = 18.24\text{ m}^2 \\ 10 \text{ ^{small} spotlights + around 11.5m cove LED} \end{array} \right.$$

$$N = 10$$

$$\phi = 412\text{m}$$

$$CU = 0.7$$

$$N = 11.5\text{m}$$

$$\Phi = 800\text{lm/m}$$

$$CU = 0.45$$

$$E = \frac{(10 \times 410 \times 0.7 \times 0.85) + (11.5 \times 800 \times 0.45 \times 0.85)}{18.24}$$

$$= 327 \text{ lux}$$

Figure 5 - Master Bedroom

$$\left\{ \begin{array}{l} A = 5 \text{ m} \times 4.5 \text{ m} = 22.5 \text{ m}^2 \\ 8 \text{ small spotlights} + \text{around } 13 \text{ m cove LED} \end{array} \right.$$

$$N = 8$$

$$\phi = 410 \text{ mm}$$

$$CU = 0.7$$

$$N = 13 \text{ m}$$

$$\phi = 800 \text{ mm/m}$$

$$CU = 0.45$$

$$E = \frac{(8 \times 410 \times 0.7 \times 0.85) + (13 \times 800 \times 0.45 \times 0.85)}{22.5}$$
$$= 264 \text{ lux}$$

Figure 6 - Master Bedroom Mini Corridor

$$\left\{ \begin{array}{l} A = 2.4 \text{ m} \times 1.3 \text{ m} = 3.12 \text{ m}^2 \\ 3 \text{ small spotlights so } N = 3 \end{array} \right.$$

$$\phi = 410 \text{ mm}$$

$$CU = 0.4$$

$$E = \frac{3 \times 410 \times 0.4 \times 0.85}{3.12} = 134 \text{ lux}$$

Figure 7 - Master Bedroom Toilet

$$\rightarrow A = 2.8m \times 2.2m = 6.16 m^2$$

4 ^{small} spot lights + mirror (LED)

$$\downarrow$$
$$N = 4$$

$$\phi = 410 \text{ lm}$$

$$CU = 0.65$$

$$\downarrow$$
$$N = 1$$

$$\phi = 900 \text{ lm}$$

$$CU = 0.6$$

$$E = \frac{(4 \times 410 \times 0.65 \times 0.85) + (1 \times 900 \times 0.6 \times 0.85)}{6.16}$$

$$= 222 \text{ lux}$$

Figure 8 - Main Toilet

$$\rightarrow A = 3m \times 2m = 6m^2$$

7 ^{small} spot lights + mirror (LED)

$$\downarrow$$
$$N = 7$$

$$\phi = 410 \text{ lm}$$

$$CU = 0.65$$

$$\downarrow$$
$$N = 1$$

$$\phi = 900 \text{ lm}$$

$$CU = 0.6$$

$$E = \frac{(7 \times 410 \times 0.65 \times 0.85) + (1 \times 900 \times 0.6 \times 0.85)}{6}$$

$$= 321 \text{ lux}$$

Figure 9 - Kitchen Corridor

$$\left\{ \begin{array}{l} A = 5.8 \text{ m} \times 1.1 \text{ m} = 6.38 \text{ m}^2 \\ 7 \text{ ^{large} downlights so } N = 7 \\ \cdot \phi = 800 \text{ lm} \\ \cdot CU = 0.4 \end{array} \right.$$

$$E = \frac{7 \times 800 \times 0.4 \times 0.85}{6.38} = 298 \text{ lux}$$

Figure 10 - Laundry Room

$$\left\{ \begin{array}{l} A = 2.4 \text{ m} \times 1.8 \text{ m} = 4.32 \text{ m}^2 \\ 3 \text{ ^{large} downlights so } N = 3 \\ \cdot \phi = 800 \text{ lm} \\ \cdot CU = 0.7 \end{array} \right.$$

$$E = \frac{3 \times 800 \times 0.7 \times 0.85}{4.32} = 331 \text{ lux}$$

Figure 11 - Kitchen

$$\rightarrow A = 5 \text{ m} \times 3 \text{ m} = 15 \text{ m}^2 \quad \text{large}$$

7 ^{small} spotlights + 6 downlights

↓	↓
$N = 7$	$N = 6$
$\phi = 410 \text{ lm}$	$\phi = 800 \text{ lm}$
$CU = 0.55$	$CU = 0.7$

$$E = \frac{(7 \times 410 \times 0.55 \times 0.85) + (6 \times 800 \times 0.7 \times 0.85)}{15} = 280 \text{ lux}$$

Figures 12 & 13 - Dining Room

$$\begin{cases} A = 4.8\text{m} \times 4.2\text{m} = 20.16\text{m}^2 \\ 14\text{m Cove LED} + 3\text{m Wall Strip LED} \end{cases}$$

$$\downarrow$$
$$N = 14\text{m}$$

$$\phi = 800\text{lm/m}$$

$$CU = 0.45$$

$$\downarrow$$
$$N = 3\text{m}$$

$$\phi = 800\text{lm/m}$$

$$CU = 0.3$$

$$E = \frac{(14 \times 800 \times 0.45 \times 0.85) + (3 \times 800 \times 0.3 \times 0.85)}{20.16}$$
$$= 243 \text{ lux}$$

Figure 14 - Windowed Balcony

$$\begin{cases} A = 5\text{m} \times 1.6\text{m} = 8\text{m}^2 \\ 4 \text{ small spotlights} + \text{around } 5\text{m Cove LED} \end{cases}$$

$$\downarrow$$
$$N = 4$$

$$\phi = 410\text{lm}$$

$$CU = 0.6$$

$$\downarrow$$
$$N = 5\text{m}$$

$$\phi = 800\text{lm/m}$$

$$CU = 0.4$$

$$E = \frac{(4 \times 410 \times 0.6 \times 0.85) + (5 \times 800 \times 0.4 \times 0.85)}{8}$$
$$= 275 \text{ lux}$$

Figure 15- Guests' Toilet

$$\rightarrow A = 2\text{ m} \times 1.5\text{ m} = 3\text{ m}^2$$

1.5m Cove LED + mirror LED

$$\downarrow$$
$$N = 1.5$$

$$\phi = 800\text{ lm/m}$$

$$CU = 0.45$$

$$\downarrow$$
$$N = 1$$

$$\phi = 900\text{ lm}$$

$$CU = 0.6$$

$$E = \frac{(1.5 \times 800 \times 0.45 \times 0.25) + (1 \times 900 \times 0.6 \times 0.25)}{3}$$
$$= 306\text{ lux}$$

Figure 16- Entrance

$$A = 3\text{ m} \times 2.3\text{ m} = 6.9\text{ m}^2$$

4 ^{small} spotlights + around 7m strip LED

$$\downarrow$$
$$N = 4$$

$$\phi = 410\text{ lm}$$

$$CU = 0.5$$

$$\downarrow$$
$$N = 7\text{ m}$$

$$\phi = 800\text{ lm/m}$$

$$CU = 0.5$$

$$E = \frac{(7 \times 800 \times 0.5 \times 0.25) + (4 \times 410 \times 0.5 \times 0.25)}{6.9}$$
$$= 446\text{ lux}$$

Figures 17 & 18 - Living Room

$$\left\{ \begin{array}{l} A = 6.5 \text{ m} \times 5.2 \text{ m} = 33.8 \text{ m}^2 \\ 16 \text{ m Cove LED} + 2.4 \text{ m Wall Strip LED} + 8 \text{ small spotlights} \end{array} \right.$$

$$\downarrow$$
$$N = 16 \text{ m}$$

$$\phi = 800 \text{ lm/m}$$

$$CU = 0.45$$

$$\downarrow$$
$$N = 2.4 \text{ m}$$

$$\phi = 800 \text{ lm/m}$$

$$CU = 0.3$$

$$\downarrow$$
$$N = 8$$

$$\phi = 410 \text{ lm}$$

$$CU = 0.7$$

$$E = \frac{(16 \times 800 \times 0.45 \times 0.85) + (2.4 \times 800 \times 0.3 \times 0.85) + (8 \times 410 \times 0.7 \times 0.85)}{33.8}$$

$$= 217 \text{ lux}$$

Figure 19 - Balcony

$$\rightarrow A = 4 \text{ m} \times 1.6 \text{ m} = 6.4 \text{ m}^2$$

$$2 \text{ large downlights} \rightarrow N = 2$$

$$\phi = 800 \text{ lm}$$

$$CU = 0.55$$

$$E = \frac{(2 \times 800 \times 0.55 \times 0.85)}{6.4} = 117 \text{ lux}$$

3.2 Results Summary Table

Space	Visually assumed dimensions (m)	Area (m**2)	Visible source estimate	Calculated E (in lux)	Typical level (also in lux)	Judgement
Bedroom 1	4.5×3.8	17.1	12 Small Spotlights + 11 m Cove	368	50	Way above typical bedroom level
Bedroom Corridor	5.2×1.25	6.5	6 Small Spotlights + 5 m LED	390	30	Much higher than typical corridor level
Bedroom 2	4.8×3.8	18.24	10 Small Spotlights + 11.5 m Cove	327	50	Above typical bedroom level
Master Bedroom	5×4.5	22.5	8 Small Spotlights + 13 m Cove	264	50	High for a bedroom
Master Mini Corridor	2.4×1.3	3.12	3 Small Spotlights	134	30	Above typical corridor level
Master Toilet	2.8×2.2	6.16	4 Small Spotlights + Mirror LED	222	300	Below typical bathroom level
Main Toilet	3×2	6	7 Small Spotlights + Mirror LED	341	300	Slightly above bathroom target
Kitchen Corridor	5.8×1.1	6.38	7 Large Downlights	298	30	Above far above corridor target
Laundry Room	2.4×1.8	4.32	3 Large Downlights	331	200	Above laundry target
Kitchen	5×3	15	6 Large Downlights + 7 Small Spotlights	280	100 or 300 or 500	Near target
Dining Room	4.8×4.2	20.16	14 m Cove + 3 m wall LED	243	100 or 200	In range (slightly above 200 lx)
Windowed Balcony	5×1.6	8	4 Small Spotlights + 5 m LED	275	50-100	Higher than needed
Guests' Toilet	2×1.5	3	1.5m Cove + 1 m mirror LED	306	300	Approx. at target
Entrance	3×2.3	6.9	7 m LED + 4 Small Spotlights	446	30	Way above entrance (or corridor) need
Living Room	6.5×5.2	33.8	8 Small Spotlights + 16 m Cove + 2.4 m Wall LED	217	30	High with all lighting layers on.
Balcony	4×1.6	6.4	2 Large Downlights	117	50-100	Above usual

Part 4 – Conclusion

4.1 Overall

The apartment is not under lit in the pictures, only in 1 out of 3 bathrooms (but even those, shouldn't be called 'under lit' rather roughly 20% below their average range). Every room reaches or exceeds the typical ambient value used for its space type, but the master bedroom's bathroom. The living room, the laundry room, the dining room and balconies are in a decent range for their jobs, while the bedrooms, corridors, entrance and living room are way brighter than the minimum household lighting.

In class we said that more light is not always better but doesn't mean that the design used at Abed's home is poor, it is rather more expensive yet more flexible too, but as engineers our goal is to lower the cost all while maximizing the output's potential. The apartment uses layered lighting, ceilings provide direct light, while walls provide softer indirect light. Note that these layers can be switched separately, so as a user can select a lower ambient scene instead of turning all sources on at once. (which is technically impossible too, even if we wanted to, remember we live in Lebanon...)

4.2 Special Cases

The kitchen deserves a separate comment because the lecture gives different values for different tasks. The calculated room average is about 280 lux, which is well above the 100 lux general kitchen value and very close to the 300 lux cooktop value, but below the 500 lux preparation value. The smaller local lights along the edge are therefore important because task illuminance should be evaluated at the edge itself, not only from the average lux value of the room.

Also the master bedroom's toilet is below the typical 300 lux bathroom value at 222 lux, so the lighting in this bathroom should be increased to better match the typical recommended level.

4.3 Final Judgement

After applying the calculations, the installed lighting is adequate throughout the home. The main observation is not a shortage of light (shortage only in 1 out of 3 toilets, out of 16 spaces in the house), but that several spaces are heavily illuminated when every lighting layer is on (but Abed never turns on all lights available in a room). The most efficient operating practice is to use the different types of circuits according to the activity being performed, while keeping the higher task light levels where they are actually useful.

References

- EECE 475 Chapter 6's Indoor Lighting Calculations Slides, Dr. Malek Chebaro, Department of ECE, AUB.

- **For Small Spotlights:**

https://www.signify.com/global/prof/led-lamps-and-tubes/led-spots/philips-essential-led-spot-gu10/929001218182_EU/product?utm_source
CorePro LEDspot GU10, **4.6 W warm-white (yellowish), 410 lm.**

- **For Large Downlights:**

https://www.signify.com/global/prof/indoor-luminaires/downlights/philips-smartbright-led-downlight-dn016/929002067212_EU/product
SmartBright LED Downlight DN016, **10 W also warm-white, 800 lm.**

- **For Cove/LED Strips:**

<https://www.ledvance.com/en/gtin/4058075237223>
LEDVANCE LED STRIP SUPERIOR-800, **approximately 800 lm/m.**

- Pictures of Abdul Kader's home in Mar Elias, Beirut, Lebanon, 6th of October 2026.

Environment	Footcandles	Lux
Living Room	3	30
Bedrooms	5	50
Kitchen-General	9	100
Kitchen-Stove/Cooktop	28	300
Kitchen-Prep Counters	47	500
Dining-Informal	9	100
Dining Room-Reading/Writing	19	200
Bathrooms	28	300
Hallways	3	30
Garage-Vehicle Bays	20	200
Garage-Workbench	93	1000
Laundry Room	19	200
Basement Rec Room	14	150

Illuminance - Recommended Indoor Light Levels	
Activity	Illuminance (lx, lumen/m ²)
Public areas with dark surroundings	20 - 50
Simple orientation for short visits	50 - 100
Areas with traffic and corridors - stairways, escalators and travelators - lifts - storage spaces	100
Working areas where visual tasks are only occasionally performed	100 - 150
Warehouses, homes, theaters, archives, loading bays	150
Coffee break room, technical facilities, ball-mill areas, pulp plants, waiting rooms,	200
Easy office work	250
Class rooms	300
Normal office work, PC work, study library, groceries, show rooms, laboratories, check-out areas, kitchens, auditoriums	500
Supermarkets, mechanical workshops, office landscapes	750
Normal drawing work, detailed mechanical workshops, operation theaters	1000
Detailed drawing work, very detailed mechanical works, electronic workshops, testing and adjustments	1500 - 2000
Performance of visual tasks of low contrast and very small size for prolonged periods of time	2000 - 5000
Performance of very prolonged and exacting visual tasks	5000 - 10000
Performance of very special visual tasks of extremely low contrast and small size	10000 - 20000