Question 1:

```
lambda1 = 1550e-9;
lambda2 = 1064e-9;
R_InGaAs_lambda1 = 0.95;
R_Ge_lambda1 = 0.92;
R_InGaAs_lambda2 = 0.7;
R_Ge_lambda2 = 0.5;
R_SiE_lambda2 = 0.53;
R_SiC_lambda2 = 0.18;
ip_lambda1 = 10e-9;
h = 6.626e-34;
c = 3e8;
q = 1.6 * 1e-19;


fprintf('For λ = 1550nm:');
```

```
For λ = 1550nm:
```

```
P0_InGaAs = ip_lambda1 / R_InGaAs_lambda1;
P0_Ge = ip_lambda1 / R_Ge_lambda1;
fprintf('\tInGaAs P0 value: %.2f nm', P0_InGaAs * 1e9);
```

```
    InGaAs P0 value: 10.53 nm
```

```
fprintf('\tGe P0 value: %.2f nm', P0_Ge * 1e9);
```

```
    Ge P0 value: 10.87 nm
```

```
% Since the R values of the others are not available at λ = 1550nm, the P0 values
will be infinite.
QE_InGaAs = (R_InGaAs_lambda1 * h * c) / (q * lambda1);
QE_Ge = (R_Ge_lambda1 * h * c) / (q * lambda1);
fprintf('\tInGaAs QE value: %% %.2f', QE_InGaAs * 100);
```

```
    InGaAs QE value: % 76.15
```

```
fprintf('\tGe QE value: %% %.2f', QE_Ge * 100);
```

```
    Ge QE value: % 73.74
```

```


fprintf('For λ = 1064nm:');
```

```
For λ = 1064nm:
```

```
ip_lambda2_InGaAs = P0_InGaAs * R_InGaAs_lambda2;
ip_lambda2_Ge = P0_Ge * R_Ge_lambda2;
fprintf('\tInGaAs ip value: %.2f nA', ip_lambda2_InGaAs * 1e9);
```

```
    InGaAs ip value: 7.37 nA
```

```
fprintf('\tGe ip value: %.2f nA', ip_lambda2_Ge * 1e9);
```

```
Ge ip value: 5.43 nA
```

Question 2:

```
% Material Properties of Zinc Oxide:
% - Crystal Structure: Zinc oxide has a wurtzite crystal structure.
% - Bandgap Energy: It is known for its bandgap energy of around 3.2 eV.
% - Band Structure: Zinc oxide exhibits high conductivity and a wide bandgap.
% - Refractive Index Curve: It has a high refractive index in the optical range,
%   approximately between 2.013 and 2.029.

% Pros and Cons of Zinc Oxide in Optoelectronics:
% Pros:
% - High Refractive Index: Useful for optical devices due to its high refractive
index.
% - Wide Bandgap: Suitable for UV and visible light sources.
% - Low Cost: Cheaper compared to other semiconductors.
% - Low Defect Density: Allows the production of high-quality substrates with low
defect density.
% Cons:
% - P-type Material Production Difficulty: Producing p-type zinc oxide can be
challenging.
% - Stability Issues: Zinc oxide may face stability issues under certain conditions.

% N-type and P-type Doping Possibilities:
% - N-type Doping: Various dopant materials can be used for n-type doping in zinc
oxide.
% - P-type Doping: There are challenges in achieving p-type doping in zinc oxide,
%   but it is possible using specific defect complexes.

% Zinc Oxide PN Junction Properties:
% - A basic zinc oxide PN junction is formed by the combination of n-type and
p-type materials.
%   This junction facilitates light emission as electrons move to the p-type
material.

% Applications of Zinc Oxide in UV and Visible Light Sources:
% - UV Lasers and LEDs: Zinc oxide is used in the production of UV light sources
such as lasers and LEDs.
% - Visible Light Sources: It is also utilized in visible light sources.
```

Question 3:

```
k_B = 1.38e-23;
h = 6.626e-34;
c = 3e8;
q = 1.6 * 1e-19;
A = 9.4e-4;
```

```
B = 290;
E_G0 = 1.728;
T_values = [-40 + 273, 25 + 273, 85 + 273];
lambda0 = zeros(size(T_values));
delta_lambda = zeros(size(T_values));


for i = 1:length(T_values)
    T = T_values(i);
    E_G = E_G0 - ((A * T^2) / (B + T));
    lambda0(i) = (h * c) / (E_G * q);
    delta_E = 2.8 * k_B * T;
    delta_lambda(i) = (delta_E * (lambda0(i))^2) / (h * c);
    delta_lambda(i) = delta_lambda(i) * 1e9;
end


fprintf('AlGaAs IR LED:\n');
```

```
AlGaAs IR LED:
```

```
fprintf('T (°C)\t\tLambda0 (nm)\tDeltaLambda (nm)\n');
```

```
T (°C)          Lambda0 (nm)    DeltaLambda (nm)
```

```
for i = 1:length(T_values)
    fprintf('%d\t\t%.2f\t\t%.2f\n', T_values(i) - 273, lambda0(i) * 1e9,
delta_lambda(i));
end
```

```
-40        761.99        26.30
25        783.32        35.54
85        805.65        45.17
```