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**[Problem 1]**

**(*1.1*)**

Take derivative of the Lagrangian w.r.t and set to 0:

Since , so we know:

So:

Moreover, also because of , and because of the Complementary slackness, , thus . Because , hence:

Plug in and back:

Thus, we had proven that:

**(*1.2*)**

The Lagrangian of this problem is:

Take derivative of the Lagrangian w.r.t and set to 0:

Because , and because of the Complementary slackness, , thus . Because , hence:

Since , so we know:

Thus:

Plug in back:

Thus, we had proven that:

**(*1.3*)**

The Lagrangian of this problem is:

Take derivative of the Lagrangian w.r.t and set to 0:

Because , and because of the Complementary slackness, , thus . Because , hence:

Since , so we know:

Thus:

Plug in back:

Thus, we had proven that:

**[Problem 2]**

To find , we only need to solve:

The Lagrangian of this problem is:

Take derivative of the Lagrangian w.r.t and set to 0:

Because , and because of the Complementary slackness, , thus . Because , hence:

Thus:

Plug back in, we have:

We know:

Thus:

Thus, we had proven that:

From the problem, we know:

Thus,

Take derivative of w.r.t and set to 0:

Thus:

And we can observe that:

The original is equivalent to:

And, if we take derivative of it w.r.t and set to 0:

Thus:

**[Problem 3]**

**(*3.1*)**

is 0 since when , we set . indicates that , and it further indicates that:

When , can be either 0 or 1 with no interferes. Thus:

**(*3.2*)**

Since when , can only be 1 (as we had proven in 3.1), thus:

**(*3.3*)**

*π* doesn’t have constraints, so we can just take derivative w.r.t it:

And set it to 0:

*λ* doesn’t have constraints, so we can just take derivative w.r.t it:

And set it to 0:

**(*3.4*)**