Q3) a- Give one example where separation holds but not sufficiency

Separation equation: P(C|Y, gender=`Male/Female`) = P(C|Y)

Sufficiency equation: P(Y| C, gender=`Male/Female`) = P (Y|C)

C= BMI and Y=Hyperlipidemia and A=Gender

Separation Check

	Hyperlipidemia= YES	Hyperlipidemia= NO
BMI = ~18.5	P(C=`~18.5`|Y= YES, gender=`Male`) = **0.1985297** P(C=`~18.5`|Y= YES)= **0.1985297**	P(C=`~18.5`|Y=NO,gender=`Male`) = **0.49179708** P(C=`~18.5`|Y=NO)=**0.49179708**
BMI = ~24.0	P(C=`~24.0`|Y= YES, gender=`Male`) = **0.4696328** P(C=`~24.0`|Y= YES)= **0.4696328**	P(C=`~18.5`|Y=NO,gender=`Male`) = **0.36267231** P(C=`~18.5`|Y=NO)=**0.36267231**
BMI = ~28.0	P(C=`~28.0`|Y= YES, gender=`Male`) = **0.32815359** P(C=~28.0|Y= YES)= **0.32815359**	P(C=`~18.5`|Y=NO,gender=`Male`) = **0.119463616** P(C=`~18.5`|Y=NO)= **0.119463616**
BMI = <18.5	P(C=`<18.5`|Y= YES, gender=`Male`) = **0.003683854** P(C=`<18.5`|Y= YES)= **0.0036838540**	P(C=`~18.5`|Y=NO,gender=`Male`) = **0.0260669856** P(C=`~18.5`|Y=NO)=**0.0260669856**

The right-hand side and left-hand side of the separation equation are equal for all values; **hence separation holds**. To ensure the conditional independence of BMI and gender, the value of gender was set to ‘Female’ and the results were exactly like the table above.

Sufficiency check

A=Gender=’Male’

	BMI = ~18.5	BMI = ~24.0	BMI = ~28.0	BMI = <18.5
Hyperlipidemia= YES	P(Y=’YES’| C=~18.5, gender=`Male`)= **0.24110864246533822** P(Y=’YES’|C=`~18.5`)= **0.21560500000000002**	P(Y=’YES’| C=~24.0, gender=`Male`)= **0.5047417852429753** P(Y=’YES’|C=`~24.0`)= **0.46857000000000004**	P(Y=’YES’| C=~28.0, gender=`Male`)= **0.6837341865229888** P(Y=’YES’|C=`~28.0`) **0.6516120000000001**	P(Y=’YES’| C=<18.5, gender=`Male`)= **0.10009280710767367** P(Y=’YES’|C=`<18.5`)= **0.08777999999999998**
Hyperlipidemia= NO	P(Y=`NO`| C=~18.5, gender=`Male`)= **0.7588913575346617** P(Y=`NO`|C=`~18.5`)= **0.784395**	P(Y=`NO`| C=~24.0, gender=`Male`)= **0.49525821475702475** P(Y=`NO`|C=`~24.0`)= **0.5314300000000001**	P(Y=`NO`| C=~28.0, gender=`Male`)= **0.31626581347701127** P(Y=`NO`|C=`~28.0`) **0.348388**	P(Y=`NO`| C=<18.5, gender=`Male`)= **0.8999071928923262** P(Y=`NO`|C=`<18.5`) **0.91222**

A=Gender=’Female’

	BMI = ~18.5	BMI = ~24.0	BMI = ~28.0	BMI = <18.5
Hyperlipidemia= YES	P(Y=’YES’| C=~18.5, gender=`Female `)= **0.18899641307583723** P(Y=’YES’|C=`~18.5`)= **0.21560500000000002**	P(Y=’YES’| C=~24.0, gender=` Female `)= **0.4277674560469438** P(Y=’YES’|C=`~24.0`)= **0.46857000000000004**	P(Y=’YES’| C=~28.0, gender=` Female `)= **0.6132638858790895** P(Y=’YES’|C=`~28.0`) **0.6516120000000001**	P(Y=’YES’| C=<18.5, gender=` Female `)= **0.07542975141421693** P(Y=’YES’|C=`<18.5`)= **0.08777999999999998**
Hyperlipidemia= NO	P(Y=`NO`| C=~18.5, gender=`Female`)= **0.8110035869241627** P(Y=`NO`|C=`~18.5`)= **0.784395**	P(Y=`NO`| C=~24.0, gender=` Female `)= **0.5722325439530562** P(Y=`NO`|C=`~24.0`)= **0.5314300000000001**	P(Y=`NO`| C=~28.0, gender=` Female `)= **0.3867361141209104** P(Y=`NO`|C=`~28.0`) **0.348388**	P(Y=`NO`| C=<18.5, gender=` Female `)= **0.924570248585783** P(Y=`NO`|C=`<18.5`) **0.91222**

Sufficiency does not hold since the left hand side and right hand side of the equation are not equal.

Q3) b- Give one example where sufficiency holds but not separation

Separation equation: P(C|Y, gender=`Male/Female`) = P(C|Y)

Sufficiency equation: P(Y| C, gender=`Male/Female`) = P (Y|C)

C= Hyperlipidemia and Y=Region and A=Gender

Sufficiency Check

	Hyperlipidemia=YES	Hyperlipidemia=NO
Region= Countryside	P(Y=`Countryside`| C=`YES`, gender=`Male`)= **0.4967974089058388** P(Y=`Countryside`| C=`YES`)= **0.4967974089058388**	P(Y=`Countryside`| C=` NO `, gender=`Male`)= **0.467759242485746** P(Y=`Countryside`| C=` NO `)= **0.467759242485746**
Region= City	P(Y=` City `| C=`YES`, gender=`Male`)= **0.503202591094161** P(Y=` City `| C=`YES`)= **0.503202591094161**	P(Y=` City `| C=` NO `, gender=`Male`)= **0.5322407575142535** P(Y=` City `| C=` NO `)= **0.5322407575142535**

The right side of the sufficiency equation and the left side are equal for all values **hence sufficiency holds**. To ensure conditional independency between Region and gender, gender was set to female and the results were exactly like the table above.

Separation Check with gender=`Male`

	Region= Countryside	Region= City
Hyperlipidemia=YES	P(C=`YES`|Y=`Countryside`, gender=`Male`)= **0.4553058308498477 7** P(C=`YES`|Y=`Countryside`)= **0.41967472381515214**	P(C=`YES`|Y=` City `, gender=`Male`)= **0.4266366780681491** P(C=`YES`|Y=` City `)= **0.391636012419724**
Hyperlipidemia=NO	P(C=` NO `|Y=`Countryside`, gender=`Male`)= **0.5446941691501523** P(C=` NO `|Y=`Countryside`)= **0.580325276184848**	P(C=` NO `|Y=` City `, gender=`Male`)= **0.573363321931851** P(C=` NO `|Y=` City `)= **0.608363987580276**

Separation Check with gender=`Female `

	Region= Countryside	Region= City
Hyperlipidemia=YES	P(C=`YES`|Y=`Countryside`, gender=`Female `)= **0.38008473760328293** P(C=`YES`|Y=`Countryside`)= **0.41967472381515214**	P(C=`YES`|Y=` City `, gender=` Female `)= **0.3530817658296224** P(C=`YES`|Y=` City `)= **0.391636012419724**
Hyperlipidemia=NO	P(C=` NO `|Y=`Countryside`, gender=` Female `)= **0.619915262396717** P(C=` NO `|Y=`Countryside`)= **0.580325276184848**	P(C=` NO `|Y=` City `, gender=` Female `)= **0.6469182341703775** P(C=` NO `|Y=` City `)= **0.608363987580276**

The right hand side and left hand side of the separation equation are not equal **hence Separation does not hold.**