INSTRUCTIONS:

Fill out the hazard analysis and risk assessment below.

HA-001 should be for the lane departure warning function as discussed in the lecture.

HA-002 should be for the lane keeping assistance function as discussed in the lecture.

Then come up with your own situations and hazards for the lane assistance system. Fill in the HA-003 and HA-004 rows.

When finished, export your spreadsheet as a pdf file so that a reviewer can easily see your work.

Hazard ID	Situational Analysis							Hazard Identification						Hazardous Event Classification						Determination of ASIL and Safety Goals	
	Operational Mode	Operational Scenario	Environmental Details	Situation Details	Other Details (optional)	Item Usage (function)	Situation Description	Function	Deviation	Deviation Details	Hazardous Event (resulting effect)	Event Details	Hazardous Event Description	Exposure (of situation)	Rationale (for exposure)	Severity (of potential harm)	Rationale (for severity)	Controllability (of hazardous event)	Rationale (for controllability)	ASIL Determination	Safety Goal
HA-001	OM03 - Normal driving	OS04 - Highway	EN06 - Rain (slippery road)	SD02 - High speed		IU01 - Correctly used	Normal Driving on Highway during Rain (slippery road) with high speed and correctly used system	Lane Departure Warning (LDW) function shall apply an oscillating steering torque to provide the driver with haptic feedback	DV04 - Actor effect is too much	The LDW function applies an oscillating torque with very high torque (above limit)	EV00 - Collision with other vehicle	High haptic feedback can affect driver's ability to steer as intended. The driver could lose control of the vehicle and collide with another vehicle or with road infrastructure.	The LDW function applies too high an oscillating torque to the steering wheel (above limit).	E3 - Medium probability	Rainy days occur on medium probability	S3 - Life-threatening or fatal injuries	Accidents on highway at high speed can be life threatening	C3 - Difficult to control or uncontrollable	Since the road is slippery, it will be difficult to control	C	The Oscillating steering torque from the LDW function shall be limited
HA-002	OM03 - Normal driving	OS04 - Highway	EN01 - Normal conditions	SD02 - High speed		IU02 - Incorrectly used	Normal Driving on Highway in normal condition with high speed and incorrectly used system	Lane Keeping Assistance (LKA) function shall apply the steering torque when active in order to stay in ego lane	DV03 - Function always activated	LKS function is activated even when the lane is not being crossed	EV00 - Collision with other vehicle	LKS could try to change the lane even though the driver has not intended to change and this might cause ego vehicle to cross lane and hit other vehicles or road infrastructure	LKS function is activated even when the lane is not being crossed	E4 - High probability	Normal driving on normal condition are high probability	S3 - Life-threatening or fatal injuries	Accidents on highway at high speed can be life threatening	C2 - Normally controllable	Since the conditions on the road are normal, it could be normally controllable	C	LKS shall be time limited
HA-003	OM04 - Backward driving	OS03 - Country Road	EN01 - Normal conditions	SD01 - Low speed		IU01 - Correctly used	Driving Backwards on a country road in normal condition at high speed and correctly used system	Lane Keeping Assistance (LKA) function shall apply the steering torque when active in order to stay in ego lane	DV02 - Function unexpectedly activated	LKS function is activated even when the function is not intended to get activated while going reverse	EV02 - Collision with pedestrian	LKS could apply reverse torque to the steering wheel and tend to move in opposite direction and hit pedestrian in the blind spots	LKS function is activated even when the function is not intended to get activated while going reverse	E3 - Medium probability	Backward driving on lane roads are medium probability	S1 - Light and moderate injuries	Since the speed will be low while driving backwards the harm will be relatively less	C3 - Difficult to control or uncontrollable	Driving in backward direction is more difficult than driving forward	A	LKS and LDW shall be deactivated when going backwards
HA-004	OM03 - Normal driving	OS03 - Country Road	EN04 - Snowfall (degraded view)	SD02 - High speed		IU01 - Correctly used	Normal Driving on a country road during snowfall at high speed and correctly used system	Lane Keeping Assistance (LKA) function shall apply the steering torque when active in order to stay in ego lane	DV10 - Actor effect is reverse	LKS function applies reverse torque for steering wheel	EV04 - Car comes off the road	LKS could try to change the lane even though the driver has not intended to change and this might cause ego vehicle to come off the road or hit pedestrian	LKS function applies reverse torque for steering wheel	E3 - Medium probability	Snow occur on medium probability	S2 - Severe and life-threatening injuries	During sensing conditions, the driver might loose control and can hit pedestrians, other vehicles or road infrastructure	C3 - Difficult to control or uncontrollable	In snowy roads, the wheels slip and will be difficult to control the vehicle	B	LKS and LDW shall be deactivated if the road is covered with snow and lanes are not detected

EXAMPLE DISCUSSED IN THE PROJECT INSTRUCTIONS - H

Hazard ID	
	Operational Mode
HA-001	Normal Driving

MORE EXAMPLES - Headlamp System

Hazard ID	
	Operational Mode
HA-001	OM03 - Normal Driving
HA-002	OM03 - Normal Driving
HA-003	OM03 - Normal Driving
HA-004	OM03 - Normal Driving
HA-005	OM03 - Normal Driving

Headlamp System

Si	
Operational Scenario	**Environmental Details**
City Road	Normal Conditions

S	
Operational Scenario	**Environmental Details**
OS01 - City Road	EN01 - Normal conditions
OS01 - City Road	EN04 - Snowfall (degraded view)
OS03 - Highway	EN04 - Snowfall (degraded view)
OS02 - Country Road	EN01 - Normal conditions
OS02 - Country Road	EN04 - Snowfall (degraded view)

tuational Analysis

Situation Details (optional)	Other Details (optional)	Item Usage (function)
Low Speed	Night time + Obstacle on the road	Correctly Used

ituation Analysis

Situation Details (optional)	Other Details (optional)	Item Usage (function)
SD03 - Low speed	Night time + Obstacle on the road	IU01 - Correctly used
SD03 - Low speed	the road and no other	IU01 - Correctly used
SD03 - High speed	Night time + Obstacle on the road or upcoming curve	IU01 - Correctly used
SD02 - High speed	Night time + Oncoming vehicle	IU01 - Correctly used
SD04 - High speed	the road and no other	IU01 - Correctly used

Situation Description	Function
Conditions at Low Speed at Night with an	Low beam illuminates the roadway in the dark

Situation Description	Function
Normal Driving on City Road during Normal conditions with Low speed (Night time + Obstacle on the road)	Low beam illuminates the roadway in the dark
(degraded view) with Low speed (Night time + Obstacle on the road and no other illumination	Low beam illuminates the roadway in the dark
(degraded view) with High speed (Night time +	Low beam illuminates the roadway in the dark
conditions with High speed (Night time +	Low beam illuminates the roadway in the dark
Snowfall (degraded view) with High speed (Night time + Obstacle on the road and no other	Low beam illuminates the roadway in the dark

Hazard Id	
Deviation	**Deviation Details**
Function not activated	Both headlights stop working

Hazard Id	
Deviation	**Deviation Details**
DV01 - Function not activated	Both headlights stop working
DV01 - Function not activated	Both headlights stop working
DV01 - Function not activated	Both headlights stop working
DV01 - Function not activated	Both headlights stop working
DV01 - Function not activated	Both headlights stop working

entification

Hazardous Event (resulting effect)	Event Details	Hazardous Event Description
Front collision with obstacle	the obstacle with injury	Total loss of low beam

entification

Hazardous Event (resulting effect)	Event Details	Hazardous Event Description
EV04 - Front collision with obstacle	Vehicle crashes into the obstacle with injury to driver	Total loss of low beam
EV04 - Front collision with obstacle	the obstacle with injury	Total loss of low beam
EV04 - Front collision with obstacle	infrastructure with injury	Total loss of low beam
EV08 - Collision with other vehicle	the oncoming vechile	Total loss of low beam
EV04 - Front collision with obstacle	infrastructure with injury	Total loss of low beam

Exposure (of situation)	Rationale (for exposure)
E4 - High probability	night driving in the city is a regular activity

Exposure (of situation)	Rationale (for exposure)
E4 - High probability	night driving in the city is a regular activity
E1 - Very low probability	completely unilluminated roads
E2 - Low probability	driving, however, heavy snow
E4 - High probability	country driving is part of regular driving
E2 - Low probability	driving, however, heavy snow

Hazardous Event Classification	
Severity (of potential harm)	**Rationale (for severity)**
S1 - Light and moderate injuries	In city traffiic, speed of vehicle is expected to be low

Hazardous Event Classification	
Severity (of potential harm)	**Rationale (for severity)**
S1 - Light and moderate injuries	In city traffiic, speed of vehicle is expected to be low
S1 - Light and moderate injuries	In city traffiic, speed of vehicle is expected to be low
S3 - Life-threatening or fatal injuries	On highway speed of vehicle is expected to be high
S3 - Life-threatening or fatal injuries	On country roads speed of vehicle is expected to be high
S3 - Life-threatening or fatal injuries	On country roads speed of vehicle is expected to be high

Controllability (of hazardous event)	Rationale (for controllability)
C0 - Controllable in general	control the situation by applying brakes and there is additional illmunitation on city

Controllability (of hazardous event)	Rationale (for controllability)
C0 - Controllable in general	At city speed, most drivers will be able to control the situation by applying brakes and there is additional illmunitation on city roads
C1 - Simply controllable	drivers usually drive at lower end of city speeds and hence are expected to be
C2 - Normally controllable	illumination on road and hence >90% drivers are able to brake and control the
C1 - Simply controllable	road, it will be difficult for the average
C3 - Difficult to control or uncontrollable	road, it will be difficult for the average

Determination of ASIL and Safety Goals	
ASIL Determination	**Safety Goal**
QM	Total Loss of Beam Shall Be Prevented

Determination of ASIL and Safety Goals	
ASIL Determination	**Safety Goal**
QM	Total loss of low beam shall be prevented
QM	Total loss of low beam shall be prevented
A	Total loss of low beam shall be prevented
B	Total loss of low beam shall be prevented
B	Total loss of low beam shall be prevented

Hazard & Risk Analysis Defir

Operational Mode

ID	Mode
OM01	Parked
OM02	Ignition on
OM03	Normal driving
OM04	Backward driving
OM05	Degraded driving
OM06	Towing (active)
OM07	Towing (passive)
OM08	Service
OM09	N/A

Operational Scenario

ID	Scenario
OS01	Any Road
OS02	City Road
OS03	Country Road
OS04	Highway
OS05	Mountain Pass
OS06	Off Road
OS07	Road with gradient
OS08	Road with bump
OS09	Road tunnel
OS10	Road with construction site
OS11	N/A

Situation Details

ID	Scenario
SD01	Low speed
SD02	High speed
SD03	Normal acceleration
SD04	High acceleration
SD05	Normal braking
SD06	High braking
SD07	N/A

Item Usage

ID	Mode
IU01	Correctly used
IU02	Incorrectly used
IU03	N/A

Environmental Details

ID	Scenario
EN01	Normal conditions
EN02	Sun blares (degraded view)
EN03	Fog (degraded view)
EN04	Snowfall (degraded view)
EN05	Cross-wind (lateral force)
EN06	Rain (slippery road)

EN07	Snow (slippery road)
EN08	Glace (slippery road)
EN09	N/A

nitions

Remarks
Car is parked, ignition is off
Car is parked, ignition is on
Car is driving
Car is driving
Limp home mode
Towing another car
Beeing towed by another car
Vehicle is in repair garage
not applicable or not relevant

Remarks
road type
road type
road type
road type
road type
road type
road attribute
road attribute
road attribute
road attribute
not applicable or not relevant

Remarks
driving attribute
driving attribute
driving attribute
driving attribute
driving attribute
driving attribute
not applicable or not relevant

Remarks
Intended usage
Unintended usage (foreseeable)
not applicable or not relevant

Remarks
weather attribute
weather attribute
weather attribute
weather attribute
weather attribute
road attribute

road attribute
road attribute
not applicable or not relevant

Reference
OM01 - Parked
OM02 - Ignition on
OM03 - Normal driving
OM04 - Backward driving
OM05 - Degraded driving
OM06 - Towing (active)
OM07 - Towing (passive)
OM08 - Service
OM09 - N/A

Reference
OS01 - Any Road
OS02 - City Road
OS03 - Country Road
OS04 - Highway
OS05 - Mountain Pass
OS06 - Off Road
OS07 - Road with gradient
OS08 - Road with bump
OS09 - Road tunnel
OS10 - Road with construction site
OS11 - N/A

Reference
SD01 - Low speed
SD02 - High speed
SD03 - Normal acceleration
SD04 - High acceleration
SD05 - Normal braking
SD06 - High braking
SD07 - N/A

Reference
IU01 - Correctly used
IU02 - Incorrectly used
IU03 - N/A

Reference
EN01 - Normal conditions
EN02 - Sun blares (degraded view)
EN03 - Fog (degraded view)
EN04 - Snowfall (degraded view)
EN05 - Cross-wind (lateral force)
EN06 - Rain (slippery road)

EN07 - Snow (slippery road)
EN08 - Glace (slippery road)
EN09 - N/A

Deviation

ID	Deviation (Guideword)	Remarks
DV01	Function not activated	Activation error
DV02	Function unexpectedly activated	Activation error
DV03	Function always activated	Activation error
DV04	Actor effect is too much	Quantitative error
DV05	Actor effect is too less	Quantitative error
DV06	Actor action too early	Timing error
DV07	Actor action too late	Timing error
DV08	Actor action before	Sequence error
DV09	Actor action after	Sequence error
DV10	Actor effect is reverse	Logical error
DV11	Actor effect is wrong	Logical error
DV12	Sensor sensitivity is too high	Quantitative error
DV13	Sensor sensitivity is too low	Quantitative error
DV14	Sensor detection too early	Timing error
DV15	Sensor detection too late	Timing error
DV16	Sensor detection before	Sequence error
DV17	Sensor detection after	Sequence error
DV18	Sensor detection is reverse	Logical error
DV19	Sensor detection is wrong	Logical error
DV20	N/A	not applicable or not relevant

Hazardous Events (possibe effects)

ID	Hazardous Event	Remarks
EV-07	None	
EV-06	Front collision with oncoming traffic	
EV-05	Front collision with ahead traffic	
EV-04	Front collision with obstacle	
EV-03	Rear collision with trailing traffic	
EV-02	Side collision with other traffic	
EV-01	Side collision with obstacle	
EV00	Collision with other vehicle	
EV01	Collision with train	
EV02	Collision with pedestrian	
EV03	Car spins out of control	
EV04	Car comes off the road	
EV05	Car catches fire	
EV06	N/A	

Reference
DV01 - Function not activated
DV02 - Function unexpectedly activated
DV03 - Function always activated
DV04 - Actor effect is too much
DV05 - Actor effect is too less
DV06 - Actor action too early
DV07 - Actor action too late
DV08 - Actor action before
DV09 - Actor action after
DV10 - Actor effect is reverse
DV11 - Actor effect is wrong
DV12 - Sensor sensitivity is too high
DV13 - Sensor sensitivity is too low
DV14 - Sensor detection too early
DV15 - Sensor detection too late
DV16 - Sensor detection before
DV17 - Sensor detection after
DV18 - Sensor detection is reverse
DV19 - Sensor detection is wrong
DV20 - N/A

Reference
EV-07 - None
EV-06 - Front collision with oncoming traffic
EV-05 - Front collision with ahead traffic
EV-04 - Front collision with obstacle
EV-03 - Rear collision with trailing traffic
EV-02 - Side collision with other traffic
EV-01 - Side collision with obstacle
EV00 - Collision with other vehicle
EV01 - Collision with train
EV02 - Collision with pedestrian
EV03 - Car spins out of control
EV04 - Car comes off the road
EV05 - Car catches fire
EV06 - N/A

Exposure

ID	Description
E0	Incredible
E1	Very low probability
E2	Low probability
E3	Medium probability
E4	High probability

Severity

ID	Description
S0	No injuries
S1	Light and moderate injuries
S2	Severe and life-threatening injuries
S3	Life-threatening or fatal injuries

Controllability

ID	Description
C0	Controllable in general
C1	Simply controllable
C2	Normally controllable
C3	Difficult to control or uncontrollable

Duration (of situation)
Not specified
<1 % of average operating time
1 % to 10 % of average operating time
>10 % of average operating time

Remarks
No injuries
Light and moderate injuries
Severe and life-threatening injuries (survival probable)
Life-threatening injuries (survival uncertain), fatal injuries

Remarks
Controllable in general
99 % or more of all drivers or other traffic participants are usually
90 % or more of all drivers or other traffic participants are usually
Less than 90 % of all drivers or other traffic participants are usua

Frequency (of situation)	Reference
	E0 - Incredible
Occurs less often than once a year for the great majority of drive	E1 - Very low probability
Occurs a few times a year for the great majority of drivers	E2 - Low probability
Occurs once a month or more often for an average driver	E3 - Medium probability
Occurs during almost every drive on average	E4 - High probability

Probability of Injuries	Reference
AIS 0 and less than 10 % probability of AIS 1-6	S0 - No injuries
More than 10 % probability of AIS 1-6 (and not S2 or S3)	S1 - Light and moderate injuries
More than 10 % probability of AIS 3-6 (and not S3)	S2 - Severe and life-threatening injuries
More than 10 % probability of AIS 5-6	S3 - Life-threatening or fatal injuries

	Reference
	C0 - Controllable in general
able to avoid harm	C1 - Simply controllable
able to avoid harm	C2 - Normally controllable
lly able, or barely able, to avoid harm	C3 - Difficult to control or uncontrollable

Controllability	Exposure	Severity		
		S0	S1	S2
C1	E1	QM	QM	QM
	E2	QM	QM	QM
	E3	QM	QM	QM
	E4	QM	QM	A
C2	E1	QM	QM	QM
	E2	QM	QM	QM
	E3	QM	QM	A
	E4	QM	A	B
C3	E1	QM	QM	QM
	E2	QM	QM	A
	E3	QM	A	B
	E4	QM	B	C

S3
QM
QM
A
B
QM
A
B
C
A
B
C
D