1) ESP (Electronic Stability Program) is a commonly used active safety system in today’s automobiles so as to help the driver maintain the yaw stability of the vehicle in case of an adverse situation, such as cornering with a high speed, low friction coefficient due to slippery road conditions or changing lane with an emergency brake. The two main adverse situations related to the yaw stability of a vehicle are namely understeering and oversteering, which can be seen in Figure 1. The ESP simply operates on the principle that the required yaw moment for the yaw stability is provided by applying brake to one of the wheels of the vehicle.

![Diagram showing ESP in action](image)

**Figure 1. Use of ESP in case of Over- & Under-steering**
In Figure 2, the components, and the subsystems used by the ESP are shown.

![Figure 2. Components & Subsystems](image)

Draw a block diagram for the closed loop system that stabilizes the yaw rate as follows: The system measures the actual yaw rate with a gyro as well as the speed of the car with the speed sensors on the wheels to obtain the actual state of the vehicle. Moreover, the desired yaw rate is determined by the driver via turning the steering wheel. The steering wheel position is sensed with the help of the steering angle sensor (e.g. a potentiometer or encoder). Note that the desired yaw rate and the steering angle are related with a constant gain. Then, the actual behavior of the vehicle, together with its desired behavior, is used in the control module, which creates a suitable control signal to obtain the necessary compensating torque through the hydraulic subsystem and the brakes of the vehicle.

HINT: The speed of the vehicle has a direct effect on the yaw rate. Thus, the speed information should be used in the determination of the control input.