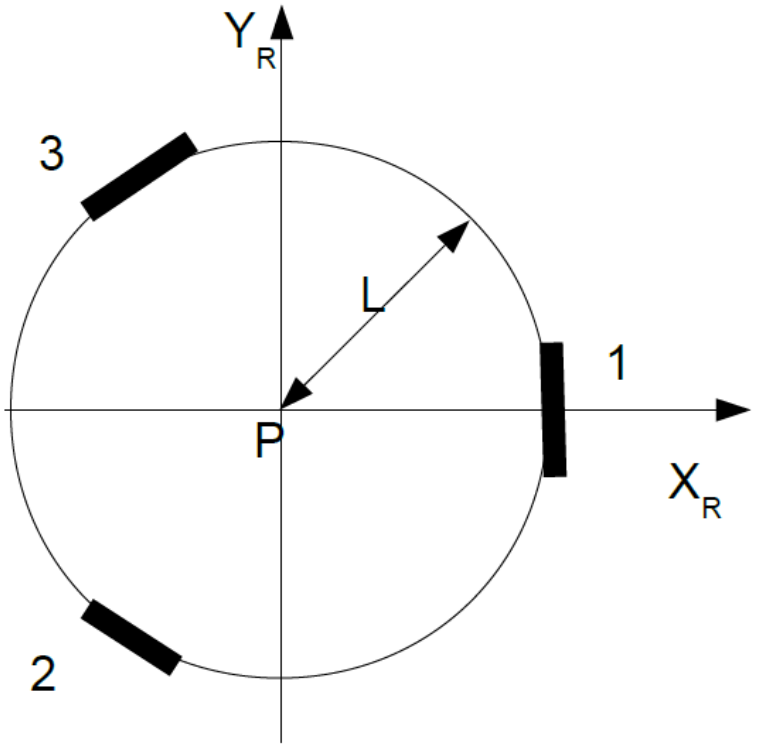
Exam 2019

Side 1

The figure below shows an omni-wheel robot. The robot has three Swedish 90-degree wheels, arranged radially symmetrically, with rollers perpendicular to each main wheel.



The robot has the following kinematics:

$$\begin{bmatrix} 0 & -2.0 & -0.3 \\ -\sqrt{3} & 1.0 & -0.3 \\ \sqrt{3} & 1.0 & -0.3 \end{bmatrix} R(\theta)\dot{\xi} = \begin{bmatrix} \omega_1 \\ \omega_2 \\ \omega_3 \end{bmatrix}$$

The robot starts so that the local and global frame are coincident and

$$(x, y, \theta) = (0,0,0)$$

Spørgsmål 1

Determine the start speed of the vehicle $(\dot{x}, \dot{y}, \dot{\theta})$ given that $(\omega_1, \omega_2, \omega_3)$ =(0.000, -2.000, 2.000)

$(\dot{x}, \dot{y}, \dot{\theta}) = (1.155, 0.000, 0.000)$

$(\dot{x}, \dot{y}, \dot{\theta}) = (0.667, 0.000, 0.000)$

$(\dot{x}, \dot{y}, \dot{\theta}) = (0.000, 0.920, 0.000)$

$(\dot{x}, \dot{y}, \dot{\theta}) = (0.000, 0.000, 2.000)$

$(\dot{x}, \dot{y}, \dot{\theta}) = (0.121, 0.143, 0.000)$

Side 2

This problem treats the issue of local stability of feedback control of robots with differential drive as described in the book 'Autonomous Mobile Robots'.
Stability is obtained if:

$$k_\rho > 0 ; k_\beta < 0 ; k_\alpha - k_\rho > 0$$

Strong stability is obtained if the following conditions are fulfilled:

$$k_\rho > 0 ; k_\beta < 0 ; k_\alpha + \frac{5}{3} k_\beta - \frac{2}{\pi} k_\rho > 0$$

Spørgsmål 2

Which set of constants fulfils the conditions for stability but **not** for strong stability?

$(k_\alpha, k_\beta, k_\rho) = (3.0, 2.0, 3.0)$

$(k_\alpha, k_\beta, k_\rho) = (8.0, -2.0, 4.0)$

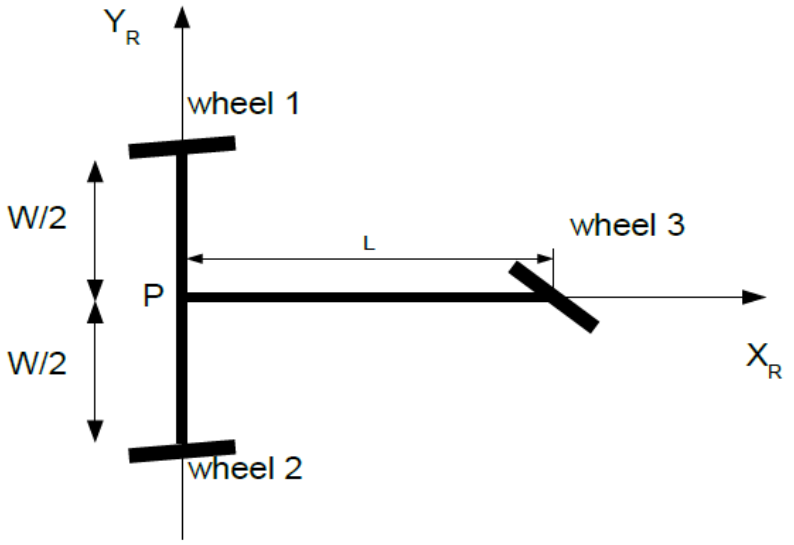
$(k_\alpha, k_\beta, k_\rho) = (7.0, -2.0, 7.1)$

$(k_\alpha, k_\beta, k_\rho) = (5.0, -2.0, 6.0)$

$(k_\alpha, k_\beta, k_\rho) = (8.0, -4.0, 5.5)$

Side 3

The figure below shows a robot with two steered standard wheels in the back and a castor wheel in the front. The two steered wheels are driven



The following data is given:
Wheel 1: $-60^0 < \beta_1 < 60^0$ steerable
Wheel 2: $120^0 < \beta_2 < 240^0$ steerable ,
L=0.3 m , w=0.30
v_1 and v_2 are the wheel speeds (m/s)

Given that $\beta_1 = -45^0, \beta_2 = 225^0, v_1 = -0.3, v_2 = 0.3$

Spørgsmål 3

Find the center of rotation (meters) and the rotational speed (rad/s)

$(x, y, \dot{\theta}) = (-0.15, 0.00, 1.41)$

$(x, y, \dot{\theta}) = (-0.30, 0.00, 0.71)$

$(x, y, \dot{\theta}) = (-0.60, 0.15, 0.71)$

$(x, y, \dot{\theta}) = (-0.15, -0.10, -0.71)$

$(x, y, \dot{\theta}) = (0.30, 0.00, 0.71)$

Side 4

Spørgsmål 4

A tactile sensor is a proprioceptive active sensor

True

False

Spørgsmål 5

A reflectivity sensor is an active exterioceptive sensor?

True

False

Spørgsmål 6

A stereo camera is a passive exteroceptive sensor?

True

False

Spørgsmål 7

A compass is an active proprioceptive sensor

True

False

Spørgsmål 8

An active sensor is emitting energy into the robot's environment

True

False

Side 5

A simplified laser scanner with 5 beams and an opening angle of +/- 60 degrees is used to detect a wall. The middle beam is pointing along the x-axis. The reading from the laser scanner is

60	30	0	-30	-60
2.5	1.0	0.75	0.80	1.0

Spørgsmål 9

Which of these lines fits the measurements best?

(r, α) = (0.74, -6 º)

(r, α) = (1.48, -6 º)

(r, α) = (0.74, 6 º)

(r, α) = (0.7, 28 º)

(r, α) = (1.0, -30 º)

Side 6

Spørgsmål 10

Calibration can be used to minimize the effect of systematic errors in a sensor

True

False

Spørgsmål 11

A camera based sensor is good at detecting transparent material such as glass.

True

False

Spørgsmål 12

A Sharp distance sensor measures distance based on the intensity of the reflected light.

True

False

Spørgsmål 13

Accuracy is related to the true value of the measured entity.

True

False

Spørgsmål 14

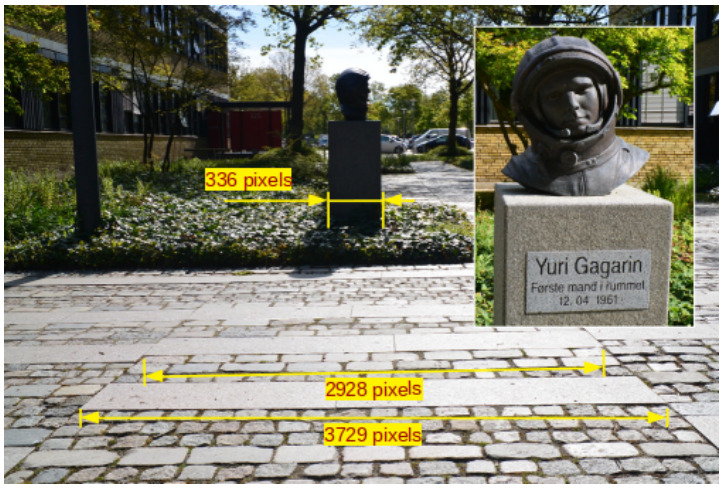
Errors in the real world are always with a Gaussian distribution

True

False

Side 7

Spørgsmål 15



What is the distance from the camera to the Gagarin statue?

The pixel width shown are for the near edge of the flat stones.
The width of the flat stones are 2.0m,
The width of the statue base is 0.5m,
The distance between the (near edge) of the flat stones are 0.7m.

23.4 m

17.4 m

10.3 m

7.1 m

4.8 m

Side 8

Spørgsmål 16

A robot with active localizer reports that the odometry
origin is at pose [x,y,Theta]=[0.6, 0.44, -31^{o}] in map coordinates.
The destination for the robot is [x,y] = [1.2, 2.2] in map coordinates.

What is the destination position in odometry coordinates?

[-0.4, 1.8]

[0, 1.86]

[1.4, 1.2]

[1.26, 1.37]

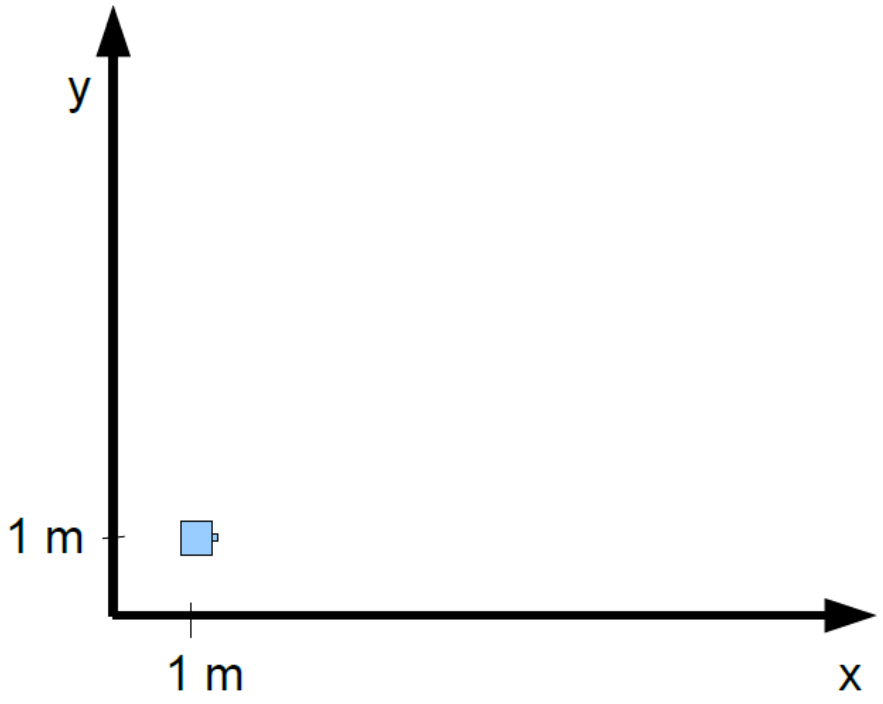
[1.56, 0.82]

Side 9

The world coordinate system has it's origo in the lower left corner of the figure. An SMR is placed (1.0, 1.0, 0.0). The SMR executes the following SMR-CL script:

```
fwd    2
turn   90
drive  2.0  3.0  90     :($targetdist <0.25)
drive  2.0  3.0  180    :($odox <0.2)
fwd    0.2
```

The odometry is assumed to be perfect



Spørgsmål 17

What is the final pose of the SMR in world coordinates (m,m, degree)?

(1.0, 4.0, 180)

(0.0 , 3.0 , 180)

(1.0, 4.0 , 90)

(4.0 , 4.0, 0)

(3.0, 1.0, -90)

Side 10

This problem is about potential field path planning. Using the notation of the book an attractive potential goal field is given:

$$U_{attr}(q)=\frac{1}{2}\rho^2(q)$$

with an attractive force:

$$F_{attr}(q)=-\nabla U_{attr}(q)$$

The repulsive field of obstacles is given by:

$$U_{rep}(q)=\begin{cases}\frac{1}{2}\left(\frac{1}{\rho(q)}-2\right)^2 & if\ \rho(q)\leq 0.5\\ 0 & if\ \rho(q)>0.5\end{cases}$$

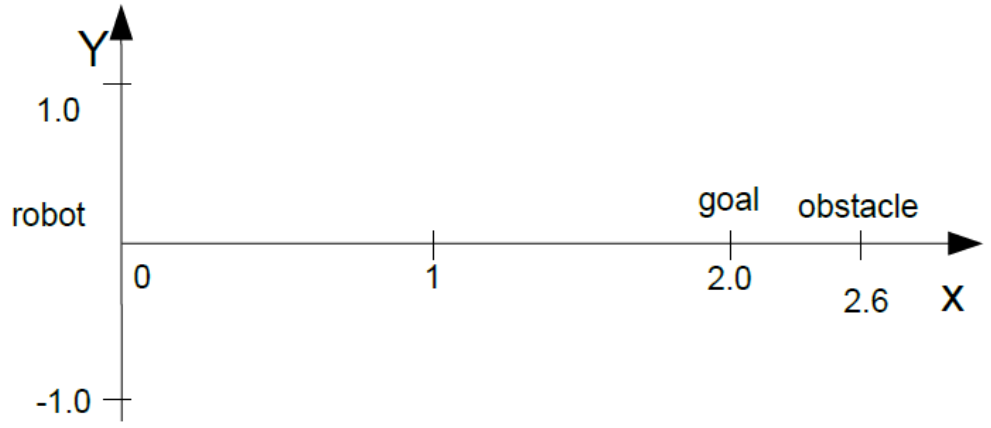
with a repulsive force:

$$F_{rep}(q)=-\nabla U_{rep}(q)$$

The resulting force is given by

$$F_{res}(q)=F_{attr}(q)+F_{rep}(q)$$

A point robot is placed in (0.0, 0.0) and a point obstacle is placed in (2.6, 0) and the goal is placed in (2.0, 0.0) as shown below.



The robot starts in (0, 0) and moves until the resulting force is 0.

Spørgsmål 18

What is the robots x-position when it stops?

2.0 m

0.0 m

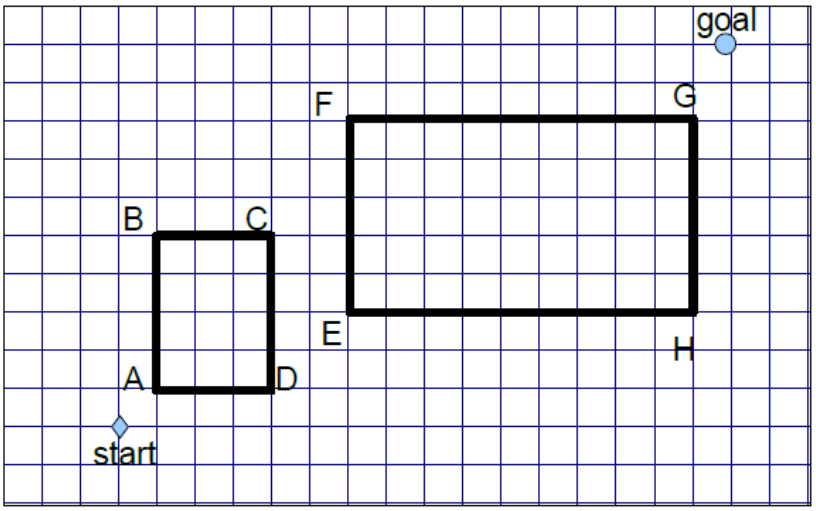
1.74 m

1.91 m

2.11 m

Side 11

The figure below shows a map with start and goal and some obstacles.



The shortest route should be found using the visibility graph method.

Spørgsmål 19

Which route is the solution?

Start-A-C-goal

Start-D-F-goal

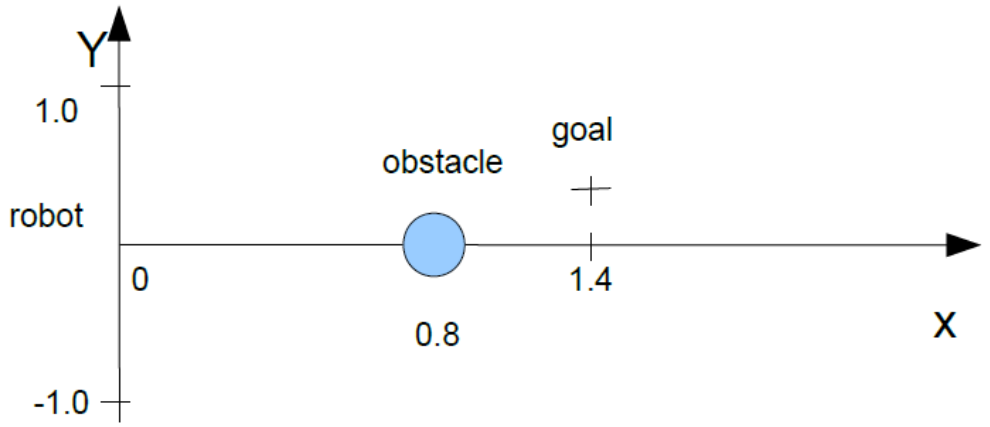
Start-D-H-goal

Start-H-goal

Start-B-F-goal

Side 12

The figure shows a point robot starting in (0.0) an obstacle with radius 0.15 m and centre at (0.8.0 , 0.0) and a goal in (1.4, 0.3) (coordinates are in meters)



Spørgsmål 20

How far will the robot have moved when it reaches the goal using bug1 algoritm?

1.43 m

2.60 m

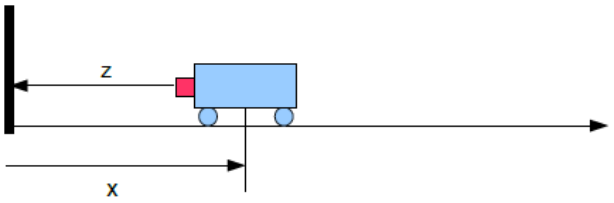
1.57 m

1.85 m

2.12 m

Side 13

A robot is standing in front of a wall. It is measuring the distance z to the wall using a laser distance sensor. The distance from the sensor to the centre of the robot is 0.26 m. The error of the sensor is zero mean Gaussian with variance $\sigma_d^2 = 0.000900\,\mathrm{m}^2$.
The start position of the robot is also Gaussian with $\sigma_{xs}^2 = 0.0500\,\mathrm{m}^2$.



To get a better estimate of x N measurements are carried out and the estimate is found using a Kalman filter. The robot is standing still between the N measurements.
How many measurements are necessary if σ_x^2 must be smaller than 0.000202?

Spørgsmål 21

How many measurements are necessary if σ_x^2 must be smaller than 0.000202?

N=1

N=2

N=3

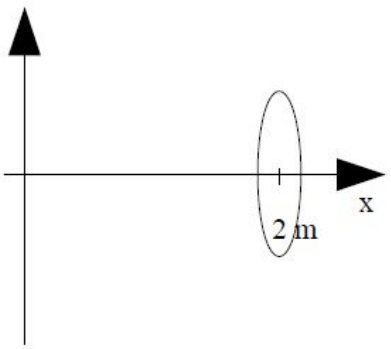
N=4

N=5

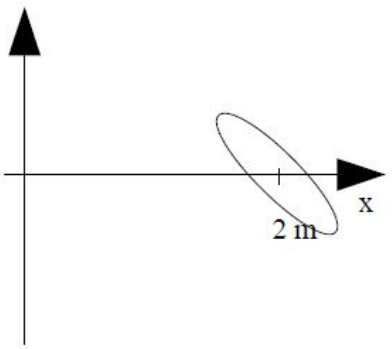
Side 14

Spørgsmål 22

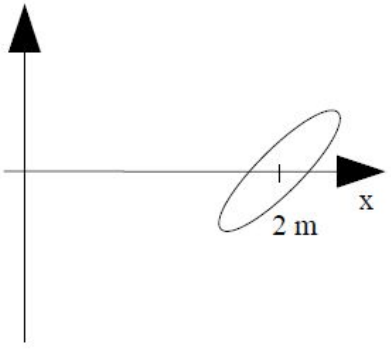
1.



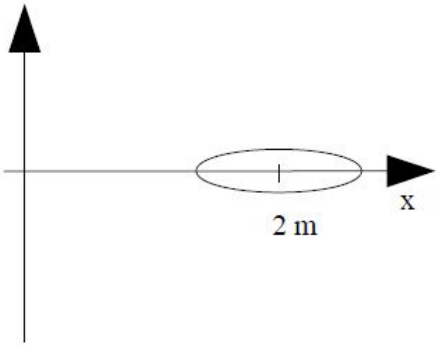
2.



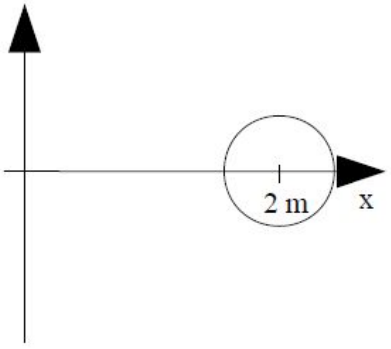
3.



4.



5.



6. Don't know

An SMR starts with pose (0,0,0) and executes the following SMR-CL program:

```
fwd -1
fwd  3
```

What is the shape of the pose uncertainty of its final position?

1

2

3

4

5

Side 15

Spørgsmål 23

A Kalman filter based localisation is computationally efficient than a Markov based.

- True
- False

Spørgsmål 24

Temporal horizon describes the amount of lookahead used by a module

- True
- False

Spørgsmål 25

A parallel control architecture is easy to verify in relation to performance.

- True
- False

Spørgsmål 26

A SLAM system always needs camera input.

- True
- False

Spørgsmål 27

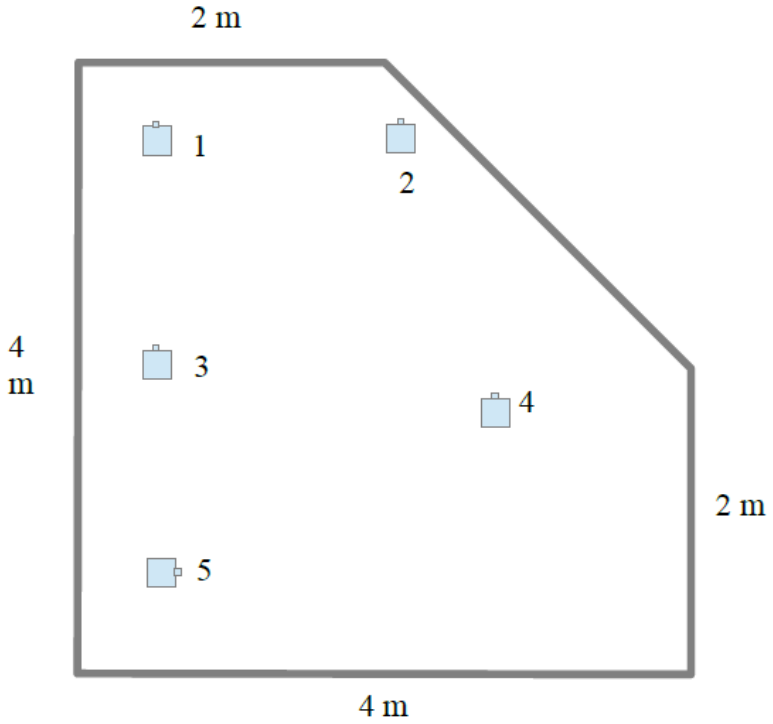
Harris corner detector is rotation invariant.

- True
- False

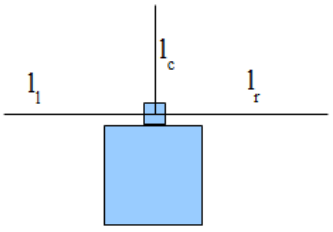
Side 16

Spørgsmål 28

A robot is located at one of the marked positions in the room shown below.



The robot uses a simple sensor to localise itself by measuring three distances to the walls, $(l_l, l_c, l_r) = (2.00, 0.50, 0.20)$



Which location fits the measurements best?

1

2

3

4

5