importance of Economics for me is basically

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Midterm Exam

1. Define a Markov Decision Process (MDP). List its key components.

→ Is an environment in which all states succeeds in retaining all relevant information. It's a Markov Reward process with decisions, because MDP policies depend on the current state to fully define the behaviour of the agent.

→ Key components: Policies, state-value function, Action-value function, Bellman Expectation Equation for MDP, Optimal state-value function, Optimal action-value function, optimal value function, optimal policy.

2. What does it mean for a process to satisfy the Markov property?

→ It succeeds in retaining all relevant information. It summarizes everything important about the complete sequence that led to it. It depends only on the present state, not on the past.

3. Explain the difference between a policy and a value function.

→ Policy is the actions that fully defines the behavior of the agent.

→ Value function is the expected return or the long-term value of a state.

4. What is the role of the discount factor (γ) in an MDP?

• What happens when $\gamma = 0$ and when $\gamma \to 1$?

→ The role of discount factor in an MDP is to ensure the math stays well-behaved. Without discounting, if reward keeps coming, the sum could be infinite.

→ When the $\gamma = 0$, it will return a 0 value.

→ When the $\gamma = 1$, it will return a same value.

5. (a) Compute the average expected reward for sunny.

$r_\pi = 0.5 \times (2) + 0.5 \times (0) = 1 + 0 = \underline{1}$

(b) Compute the average expected reward for Rainy.

$r_\pi = 0.5 \times (1) + 0.5 \times (3) = 0.5 + 1.5 = \underline{2}$

(c) Using the Bellman expectation equation, solve for V_π (sunny).

$V_1 = 1 + 0.5(0v_1 + 1v_2)$

$V_1 = 1 + 0v_1 + 0.5v_2$

$V_1 - 0v_1 - 0.5v_2 = 1$

$\boxed{\cancel{0v} 1v_1 - 0.5v_2 = 1}$

$\frac{\cancel{v}v_1}{\cancel{1}} = \frac{1 + 0.5v_2}{1}$

$V_1 = \frac{1 + 0.5(3.33)}{1} = \frac{1 + 1.665}{1} = 2.665$

$\boxed{V_\pi(\text{sunny}) = 2.665}$

~~for~~ (sunny):

$P_\pi(1,1) = 0.5 \times 0.0 + 0.5 \times 0.0 =$

$0.0 + 0.0 = \underline{0}$

$P_\pi(1,2) = 0.5 \times 1.0 + 0.5 \times 1.0 =$

$0.5 + 0.5 = \underline{1}$

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(d) Using the bellman expectation equation, solve for $v_\pi(\text{Rainy})$.

$v_2 = 2 + 0.5(1v_1 + 0v_2)$

$v_2 = 2 + 0.5v_1 + 0v_2$

$v_2 - 0.5v_1 - 0v_2 = 2$

$\boxed{-0.5v_1 + 1v_2 = 2}$

$1v_1 - 0.5v_2 = 1$

$1v_1 = \frac{1 + 0.5v_2}{1}$

$\boxed{v_1 = \frac{1 + 0.5v_2}{1}}$

for (Rainy):

$P_\pi(2,1) = 0.5 \times 1.0 + 0.5 \times 1.0 = 0.5 + 0.5 = 1$

$P_\pi(2,2) = 0.5 \times 0.0 + 0.5 \times 0.0 = 0.0 + 0.0 = 0$

$\cancel{v_\pi(\text{Rainy}) = \frac{2 - 0.5}{1} = 1.5}$

$= -0.5(1 + 0.5v_2) + 1v_2 = 2$

$= (-0.5 \times 1)(-0.5 \times 0.5v_2) + 1v_2 = 2$

$= -0.5 - 0.25v_2 + 1v_2 = 2$

$= -0.5 + (-0.25v_2 + 1v_2) = 2$

$= -0.5 + 0.75v_2 = 2$

$= 0.75v_2 = 2 + 0.5$

$\boxed{v_\pi(\text{rainy}) = \frac{2 + 0.5}{0.75} = \frac{2.5}{0.75} = 3.33}$

	$v_{k+3}(s)$
A	−3
B	−3
C	−2.94
D	−3
F	−2.375
G	−2.94
H	−2.375

6. (a) Using dynamic programming, compute the optimal state-value function $v_*(s)$ for all non-terminal states.

$v_{k+1}(A) = \frac{1}{4}[(-1 + v(A)) + (-1 + v(B)) + (-1 + v(D)) + (-1 + v(A))]$

$v_{k+1}(A) = \frac{1}{4}[(-1 + 0) + (-1 + 0) + (-1 + 0) + (-1 + 0)]$

$\boxed{v_{k+1}(A) = -1}$

$v_{k+1}(B) = \frac{1}{4}[(-1 + v(A)) + (-1 + v(C)) + (-1 + v(B)) + (-1 + v(B))]$

$= \frac{1}{4}[(-1 + 0) + (-1 + 0) + (-1 + 0) + (-1 + 0)]$

$\boxed{v_{k+1}(B) = -1}$

	$v_k(s)$	$v_{k+1}(s)$	$v_{k+2}(s)$
A	0	−1	−2
B	0	−1	−2
C	0	−1	−2
D	0	−1	−2
F	0	−1	−1.75
G	0	−1	−2
H	0	−1	−1.75

$$v_{k+1}(C) = \frac{1}{4}\left[(-1+v(B)) + (-1+v(C)) + (-1+v(F)) + (-1+v(C))\right]$$

$$= \frac{1}{4}\left[(-1+0) + (-1+0) + (-1+0) + (-1+0)\right]$$

$$\boxed{v_{k+1}(C) = -1}$$

$$v_{k+1}(D) = \frac{1}{4}\left[(-1+v(D)) + (-1+v(D)) + (-1+v(G)) + (-1+v(A))\right]$$

$$= \frac{1}{4}\left[(-1+0) + (-1+0) + (-1+0) + (-1+0)\right]$$

$$\boxed{v_{k+1}(D) = -1}$$

$$v_{k+1}(F) = \frac{1}{4}\left[(-1+v(F)) + (-1+v(F)) + (-1+v(I)) + (-1+v(C))\right]$$

$$= \frac{1}{4}\left[(-1+0) + (-1+0) + (-1+0) + (-1+0)\right]$$

$$\boxed{v_{k+1}(F) = -1}$$

$$v_{k+1}(G) = \frac{1}{4}\left[(-1+v(G)) + (-1+v(H)) + (-1+v(G)) + (-1+v(D))\right]$$

$$= \frac{1}{4}\left[(-1+0) + (-1+0) + (-1+0) + (-1+0)\right]$$

$$\boxed{v_{k+1}(G) = -1}$$

$$v_{k+1}(H) = \frac{1}{4}\left[(-1+v(G)) + (-1+v(I)) + (-1+v(H)) + (-1+v(H))\right]$$

$$= \frac{1}{4}\left[(-1+0) + (-1+0) + (-1+0) + (-1+0)\right]$$

$$\boxed{v_{k+1}(H) = -1}$$

$q(A, LEFT) = -1 + v(A)$
$= -1 + (-1)$
$\underline{q(A, LEFT) = -2}$

$q(A, RIGHT) = -1 + v(B)$
$= -1 + (-1)$
$\underline{q(A, RIGHT) = -2}$

$q(A, DOWN) = -1 + v(D)$
$= -1 + (-1)$
$\underline{q(A, DOWN) = -2}$

$q(A, UP) = -1 + v(A)$
$= -1 + (-1)$
$\underline{q(A, UP) = -2}$

$\pi(A) = \leftrightarrow \updownarrow$

$q(B,\text{LEFT}) = -1 + v(A)$
$= -1 + (-1)$
$\underline{q(B,\text{LEFT}) = -2}$

$q(B,\text{RIGHT}) = -1 + v(C)$
$= -1 + (-1)$
$\underline{q(B,\text{RIGHT}) = -2}$

$q(B,\text{DOWN}) = -1 + v(B)$
$= -1 + (-1)$
$\underline{q(B,\text{DOWN}) = -2}$

$q(B,\text{UP}) = -1 + v(B)$
$= -1 + (-1)$
$\underline{q(B,\text{UP}) = -2}$

$\pi(B) = \leftrightarrow\updownarrow$

$q(C,\text{LEFT}) = -1 + v(B)$
$= -1 + (-1)$
$\underline{q(C,\text{LEFT}) = -2}$

$q(C,\text{RIGHT}) = -1 + v(C)$
$= -1 + (-1)$
$\underline{q(C,\text{RIGHT}) = -2}$

$q(C,\text{DOWN}) = -1 + v(F)$
$= -1 + (-1)$
$\underline{q(C,\text{DOWN}) = -2}$

$q(C,\text{UP}) = -1 + v(C)$
$= -1 + (-1)$
$\underline{q(C,\text{UP}) = -2}$

$\pi(C) = \leftrightarrow\updownarrow$

$q(D,\text{LEFT}) = -1 + v(D)$
$= -1 + (-1)$
$\underline{q(D,\text{LEFT}) = -2}$

$q(D,\text{RIGHT}) = -1 + v(D)$
$= -1 + (-1)$
$\underline{q(D,\text{RIGHT}) = -2}$

$q(D,\text{DOWN}) = -1 + v(G)$
$= -1 + (-1)$
$\underline{q(D,\text{DOWN}) = -2}$

$q(D,\text{UP}) = -1 + v(A)$
$= -1 + (-1)$
$\underline{q(D,\text{UP}) = -2}$

$\pi(D) = \leftrightarrow\updownarrow$

$q(F,\text{LEFT}) = -1 + v(F)$
$= -1 + (-1)$
$\underline{q(F,\text{LEFT}) = -2}$

$q(F,\text{RIGHT}) = -1 + v(F)$
$= -1 + (-1)$
$\underline{q(F,\text{RIGHT}) = -2}$

$q(F,\text{DOWN}) = -1 + v(I)$
$= -1 + (0)$
$\underline{q(F,\text{DOWN}) = -1}$

$q(F,\text{UP}) = -1 + v(C)$
$= -1 + (-1)$
$\underline{q(F,\text{UP}) = -2}$

$\pi(F) = \downarrow$

$q(G,\text{LEFT}) = -1 + v(G)$
$= -1 + (-1)$
$\underline{q(G,\text{LEFT}) = -2}$

$q(G,\text{RIGHT}) = -1 + v(H)$
$= -1 + (-1)$
$\underline{q(G,\text{RIGHT}) = -2}$

$q(G,\text{DOWN}) = -1 + v(G)$
$= -1 + (-1)$
$\underline{q(G,\text{DOWN}) = -2}$

$q(G,\text{UP}) = -1 + v(D)$
$= -1 + (-1)$
$\underline{q(G,\text{UP}) = -2}$

$\pi(G) = \leftrightarrow\updownarrow$

$q(A, LEFT) = -1 + v(G) \qquad q(A, RIGHT) = -1 + v(I) \qquad q(A, DOWN) = -1 + v(B)$

$= -1 + (-1) \qquad = -1 + (0) \qquad = -1 + (-1)$

$\underline{q(A, LEFT) = -2} \qquad \underline{q(A, RIGHT) = -1} \qquad \underline{q(A, DOWN) = -2}$

$q(A, UP) = -1 + v(A)$

$= -1 + (-1) \qquad \pi(A) = \rightarrow$

$\underline{q(A, UP) = -2}$

$$V_{k+2}(A) = \frac{1}{4}[(-1 + V_{k+1}(A)) + (-1 + V_{k+1}(B)) + (-1 + V_{k+1}(D)) + (-1 + V_{k+1}(A))]$$

$$= \frac{1}{4}[(-1-1) + (-1-1) + (-1-1) + (-1-1)]$$

(a) $\boxed{V_{k+2}(A) = -2}$

$$V_{k+2}(B) = \frac{1}{4}[(-1 + V_{k+1}(A)) + (-1 + V_{k+1}(C)) + (-1 + V_{k+1}(B)) + (-1 + V_{k+1}(B))]$$

$$= \frac{1}{4}[(-1-1) + (-1-1) + (-1-1) + (-1-1)$$

$\boxed{V_{k+2}(B) = -2}$

$$V_{k+2}(C) = \frac{1}{4}[(-1 + V_{k+1}(B)) + (-1 + V_{k+1}(C)) + (-1 + V_{k+1}(F)) + (-1 + V_{k+1}(C))]$$

$$= \frac{1}{4}[(-1-1) + (-1-1) + (-1-1) + (-1-1)]$$

$\boxed{V_{k+2}(C) = -2}$

(b)

$$V_{k+2}(D) = \frac{1}{4}[(-1 + V_{k+1}(D)) + (-1 + V_{k+1}(D)) + (-1 + V_{k+1}(G)) + (-1 + V_{k+1}(A))]$$

$$= \frac{1}{4}[(-1-1) + (-1-1) + (-1-1) + (-1-1)]$$

$\boxed{V_{k+2}(D) = -2}$

$$V_{k+2}(F) = \frac{1}{4}[(-1 + V_{k+1}(F)) + (-1 + V_{k+1}(F)) + (-1 + V_{k+1}(I)) + (-1 + V_{k+1}(C))]$$

$$= \frac{1}{4}[(-1-1) + (-1-1) + (-1+0) + (-1-1)]$$

$\boxed{V_{k+2}(F) = -1.75}$

$$V_{k+2}(G) = \frac{1}{4}\left[(-1+V_{k+1}(G)) + (-1+V_{k+1}(H)) + (-1+V_{k+1}(G)) + (-1+V_{k+1}(D))\right]$$

$$= \frac{1}{4}\left[(-1-1)+(-1-1)+(-1-1)+(-1-1)\right]$$

$$\boxed{V_{k+2}(G) = -2}$$

$$V_{k+2}(H) = \frac{1}{4}\left[(-1+V_{k+1}(G)) + (-1+V_{k+1}(I)) + (-1+V_{k+1}(H)) + (-1+V_{k+1}(A))\right]$$

$$= \frac{1}{4}\left[(-1-1)+(-1+0)+(-1-1)+(-1-1)\right]$$

$$\boxed{V_{k+2}(H) = -1.75}$$

$q(A,\text{LEFT}) = -1 + v(A)$
$= -1 + (-2)$
$q(A,\text{LEFT}) = -3$

$q(A,\text{RIGHT}) = -1 + v(B)$
$= -1 + (-2)$
$q(A,\text{RIGHT}) = -3$

$q(A,\text{DOWN}) = -1 + v(D)$
$= -1 + (-2)$
$q(A,\text{DOWN}) = -3$

$q(A,\text{UP}) = -1 + v(A)$
$= -1 + (-2)$
$q(A,\text{UP}) = -3$

$\pi(A) = \leftarrow\uparrow\rightarrow\downarrow$

$q(B,\text{LEFT}) = -1 + v(A)$
$= -1 + (-2)$
$q(B,\text{LEFT}) = -3$

$q(B,\text{RIGHT}) = -1 + v(C)$
$= -1 + (-2)$
$q(B,\text{RIGHT}) = -3$

$q(B,\text{DOWN}) = -1 + v(B)$
$= -1 + (-2)$
$q(B,\text{DOWN}) = -3$

$q(B,\text{UP}) = -1 + v(B)$
$= -1 + (-2)$
$q(B,\text{UP}) = -3$

$\pi(B) = \leftarrow\uparrow\rightarrow\downarrow$

$q(C,\text{LEFT}) = -1 + v(B)$
$= -1 + (-2)$
$q(C,\text{LEFT}) = -3$

$q(C,\text{RIGHT}) = -1 + v(C)$
$= -1 + (-2)$
$q(C,\text{RIGHT}) = -3$

$q(C,\text{DOWN}) = -1 + v(F)$
$= -1 + (-1.75)$
$q(C,\text{DOWN}) = -2.75$

$q(C,\text{UP}) = -1 + v(C)$
$= -1 + (-2)$
$q(C,\text{UP}) = -3$

$\pi(C) = \downarrow$

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$q(D, LEFT) = -1 + v(D)$
$= -1 + (-2)$
$q(D, LEFT) = -3$

$q(D, RIGHT) = -1 + v(D)$
$= -1 + (-2)$
$q(D, RIGHT) = -3$

$q(D, DOWN) = -1 + v(G)$
$= -1 + (-2)$
$q(D, DOWN) = -3$

$q(D, UP) = -1 + v(A)$
$= -1 + (-2)$
$q(D, UP) = -3$

$\pi(D) = \leftarrow\uparrow\downarrow\rightarrow$

$q(G, LEFT) = -1 + v(G)$
$= -1 + (-2)$
$q(G, LEFT) = -3$

$q(G, RIGHT) = -1 + v(H)$
$= -1 + (-1.75)$
$q(G, RIGHT) = -2.75$

$q(G, DOWN) = -1 + v(G)$
$= -1 + (-2)$
$q(G, DOWN) = -3$

$q(G, UP) = -1 + v(D)$
$= -1 + (-2)$
$q(G, UP) = -3$

(a) $\pi(G) = \rightarrow$

$v_{k+3}(A) = \frac{1}{4}[(-1 + v_{k+2}(A)) + (-1 + v_{k+2}(B)) + (-1 + v_{k+2}(D)) + (-1 + v_{k+2}(A))]$
$= \frac{1}{4}[(-1-2) + (-1-2) + (-1-2) + (-1-2)]$
$\boxed{v_{k+3}(A) = -3}$

$v_{k+3}(B) = \frac{1}{4}[(-1 + v_{k+2}(A)) + (-1 + v_{k+2}(C)) + (-1 + v_{k+2}(B)) + (-1 + v_{k+2}(B))]$
$= \frac{1}{4}[(-1-2) + (-1-2) + (-1-2) + (-1-2)]$
(b) $\boxed{v_{k+3}(B) = -3}$

$v_{k+3}(C) = \frac{1}{4}[(-1 + v_{k+2}(B)) + (-1 + v_{k+2}(C)) + (-1 + v_{k+2}(F)) + (-1 + v_{k+2}(C))]$
$= \frac{1}{4}[(-1-2) + (-1-2) + (-1-1.75) + (-1-2)]$
$\boxed{v_{k+3}(C) = \cancel{-1.75}\ -2.94}$

$v_{k+3}(D) = \frac{1}{4}[(-1 + v_{k+2}(D)) + (-1 + v_{k+2}(D)) + (-1 + v_{k+2}(G)) + (-1 + v_{k+2}(A))]$
$= \frac{1}{4}[(-1-2) + (-1-2) + (-1-2) + (-1-2)]$
$\boxed{v_{k+3}(D) = -3}$

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$v_{k+3}(F) = \frac{1}{4}[(-1+V_{k+2}(F)) + (-1+v_{k+2}(F)) + (-1+v_{k+2}(I)) + (-1+V_{k+2}(C))]$

$= \cancel{\frac{1}{4}[(-1-2) + (-1-2) + (-1+0) + }$

$= \frac{1}{4}[(-1-1.75) + (-1-1.75) + (-1+0) + (-1-2)]$

$\boxed{v_{k+3}(F) = -2.375}$

$v_{k+3}(G) = \frac{1}{4}[(-1+v_{k+2}(G)) + (-1+v_{k+2}(H)) + (-1+v_{k+2}(G)) + (-1+v_{k+2}(D))]$

$= \frac{1}{4}[(-1-2) + (-1-1.75) + (-1-2) + (-1-2)]$

$\boxed{v_{k+3}(G) = -2.94}$

$v_{k+3}(H) = \frac{1}{4}[(-1+v_{k+2}(G)) + (-1+V_{k+2}(I)) + (-1+v_{k+2}(H)) + (-1+v_{k+2}(H))]$

$= \frac{1}{4}[(-1-2) + (-1+0) + (-1-1.75) + (-1\ 1.75)]$

$\boxed{v_{k+3}(H) = -2.375}$

$q(A, LEFT) = -1 + v(A)$
$= -1 + (-3)$
$\boxed{q(A, LEFT) = -4}$

$q(A, RIGHT) = -1 + v(B)$
$= -1 + (-3)$
$\boxed{q(A, RIGHT) = -4}$

$q(A, DOWN) = -1 + v(D)$
$= -1 - 3$
$q(A, DOWN) = -4$

$q(A, UP) = -1 + v(A)$
$= -1 + -3$
$\boxed{q(A, UP) = -4}$

$\pi(A) = \leftrightarrow\updownarrow$

$q(B)^{LEFT} = -1 + v(A)$
$= -1 + (-3)$
$q(B, LEFT) = -4$

$q(B, RIGHT) = -1 + v(C)$
$= -1 + (-2.94)$
$q(B, RIGHT) = -3.94$

$q(B, DOWN) = -1 + v(D)$
$= -1 + -3$
$q(B, DOWN) = -4$

$q(B, UP) = -1 + v(A)$
$= -1 + (-3)$
$q(B, UP) = -4$

$\pi(B) = \rightarrow$

Importance of Economics

$q(D)^{LEFT} = -1 + v(B)$
$= -1 + (-3)$
$q(D)^{LEFT} = -4$

$q(D, RIGHT) = -1 + v(D)$
$= -1 + (-3$
$q(D, RIGHT) = -4$

$q(D, UP) = -1 + v(A)$
$= -1 + (-3)$
$q(D, UP) = -4$

$q(D, DOWN) = -1 + v(G)$
$= -1 + (-2.94)$
$q(D, DOWN) = -3.94$

$\pi(D) = \downarrow$

(a)

	$V_k(s)$	$V_{k+1}(s)$	$V_{k+2}(s)$	$V_{k+3}(s)$
A	0	-1	-2	-3
B	0	-1	-2	-3
C	0	-1	-2	-2.94
D	0	-1	-2	-3
F	0	-1	-1.75	-2.375
G	0	-1	-2	-2.94
H	0	-1	-1.75	-2.375

(b)

$\pi(A) = \leftarrow \uparrow \rightarrow \downarrow$ $\pi(D) = \downarrow$ $\pi(H) = \rightarrow$

$\pi(B) = \rightarrow$ $\pi(F) = \downarrow$

$\pi(C) = \downarrow$ $\pi(G) = \rightarrow$