**Six Degrees of Kevin Bacon**

The [trivia](http://en.wikipedia.org/wiki/Trivia) [game](http://en.wikipedia.org/wiki/Game) **Six Degrees of Kevin Bacon** is based on the concept of the ***“***[***small world phenomenon***](http://en.wikipedia.org/wiki/Small_world_phenomenon)***”*** (human society is a [small world](http://en.wikipedia.org/wiki/Watts_and_Strogatz_model) type network characterized by short path lengths or links between individuals). The game rests on the assumption that any [actor](http://en.wikipedia.org/wiki/Actor) can be linked through his or her [film](http://en.wikipedia.org/wiki/Film) roles to actor [Kevin Bacon](http://en.wikipedia.org/wiki/Kevin_Bacon). The game requires players to try to connect any film actor in history to Kevin Bacon in as few links as possible.

Kevin Bacon is an actor who has achieved cult-hero status over the past few years. His first movie was ***Animal House*** (1978), followed by Friday the 13th (1980 and filmed in NJ). After coming to national attention as the star of the movie ***Footloose*** (1984), he has gone on to appear in films such as ***Tremors***, ***JFK***, ***Apollo 13***, ***A Few God Men***, ***Frost/Nixon*** and ***X-Men: First Class***.

The **Bacon Number** of an [actor](http://en.wikipedia.org/wiki/Actor) or actress is the number of degrees of separation he or she is from Bacon in terms of the movies that connect them. The higher the Bacon Number, the farther away from Kevin Bacon the actor is.

The computation of a Bacon number for actor ***X*** is a [***shortest path***](http://en.wikipedia.org/wiki/Shortest_path_problem)[***algorithm***](http://en.wikipedia.org/wiki/Algorithm) (an algorithm is a procedure or formula for solving a problem):

* Kevin Bacon himself has a Bacon Number of ***0***.
* If Actor A has been in a movie with Kevin Bacon he has a Bacon Number of **1**. If Actor B has been in a movie with Actor A but not with Kevin Bacon, his Bacon Number is ***2***.

For example, Tom Hanks has appeared in a movie with Kevin Bacon (***Apollo 13***) while Bruce Willis has never acted in the same movie as Kevin, but he has appeared with Tom Hanks (***The Bonfire of the Vanities***.) Graphically, we can label vertices with actors and connect two actors with an edge if they acted together in the same movie. Our three actors above would form a graph with two edges:



Tom Hanks has a Bacon Number of 1 while Bruce Willis’ Bacon Number is 2. An actor who has been in a movie with Bruce Willis but not Tom Hanks or Kevin Bacon would have a Bacon Number of 3: **Actor—BW—TH—KB**.

The **complete co-star graph** for the set of actors--Kevin Bacon, Tom Cruise (TC), Ashley Judd (AJ), Tom Hanks (TH), Bruce Willis (BW) and Renee Zellweger (RZ)--looks like this:



A **complete co-star graph** includes all of the direct and indirect links from each actor to Kevin Bacon and all direct (1-Links) among all of the other actors. That is, you may have to add edges if any of the 6 actors in the network with Kevin Bacon acted in movies together. **Caution**: While there may be shorter paths between some of the actors in our graph (for example, the actual shortest path between Tom Cruise and Bruce Willis is 2), we are only concerned with their relationship relative to Kevin Bacon.

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|  | **Shortest Paths Between Actors** |  |  |  |  |
| **Actor** | **KB** | **TC** | **AJ** | **TH** | **BW** | **RZ** | **EW** | **MT** | **Sum of Shortest Paths** | **# of 1-Links** | **Degree****Centrality** | **Closeness Centrality** |
| **KB** | **-** | **1** | **2** | **1** | **2** | **1** | **1** | **1** | **9** | **5** | **5/7 = 0.71** | **7/9 = 0.78** |
| **TC** | **1** | **-** | **3** | **2** | **3** | **1** | **2** | **2** | **14** | **2** | **2/7 = 0.29** | **7/14 = 0.50** |
| **AJ** | **2** | **3** | **-** | **3** | **2** | **3** | **2** | **1** | **16** | **1** | **1/7 = 0.14** | **7/16 = 0.44** |
| **TH** | **1** | **2** | **3** | **-** | **1** | **2** | **1** | **2** | **12** | **3** | **1/7 = 0.14** | **7/12 = 0.58** |
| **BW** | **2** | **3** | **2** | **1** | **-** | **3** | **1** | **1** | **13** | **3** | **3/7 = 0.43** | **7/13 = 0.54** |
| **RZ** | **1** | **1** | **3** | **2** | **3** | **-** | **2** | **2** | **14** | **2** | **2/7 = 0.29** | **7/14 = 0.50** |
| **EW** | **1** | **2** | **2** | **1** | **1** | **2** | **-** | **1** | **10** | **4** | **4/7 = 0.57** | **7/10 = 0.70** |
| **MT** | **1** | **2** | **1** | **2** | **1** | **2** | **1** | **-** | **10** | **4** | **4/7 =0.57** | **7/10 = 0.70** |

**Degree Centrality (DC)** for any actor is the number of direct connections (1-links) to other network members divided by the number of possible connections (The number of actors minus one).

**Closeness Centrality (CC)** is the number of connections for each actor divided by the shortest number of links required to connect to every other actor.

As can be expected with a network centered on Kevin Bacon, he has the highest DC and CC measures of all of the actors.

For the cinematically inclined, the movies that form the edges are:

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| **Vertex-Edge Table** | https://s-media-cache-ak0.pinimg.com/236x/50/46/20/504620ba998a45a8102a36c5adb7588b.jpg |
| **Actor Pairs (Vertices)** | **Movies (Edge)** |
| KB--TC | A Few Good Men |
| KB--RZ | My One and Only |
| KB--TH | Apollo 13 |
| KB--EW | Beyond All Boundaries |
| KB-MT | Lover Boy |
| EW-MT | Jason Alexander Joins the 99% |
| EW-BW | Sin City |
| EW-TH | Radio Flyer |
| MT-AJ | Someone Like You |
| MT-BW | Four Rooms |
| BW-TH | The Bonfires of the Vanities |
| TC-RZ | Jerry Maguire |

All you need to draw your graph is one movie that connects two actors. This does not mean that the movie you selected is the only movie where the two actors appeared together.

**How Good a Center is an Actor?**

By processing all of the 3.2 million people in the [Internet Movie Database](http://www.imdb.com/) (IMDB) you will discover that there are currently 406 people who are ***better*** centers than Kevin Bacon! What does it mean for one person to be a "better" center than another? Consider the following breakdown of people by [Bacon Number](https://oracleofbacon.org/onecenter.php?who=Kevin+Bacon) (as of January 13, 2015):

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| **Bacon Number** | **# of Actors** | This table shows that there is 1 person who can be linked in 0 steps to Kevin Bacon (Bacon himself), 3018 people who can be linked in 1 step (there are 3018 actors who were in movies with Keven Bacon), 349861 people who can be linked in 2 steps (actors who were in movies with other actors who were in movies with Kevin bacon), etc. So we can compute the *average* [Bacon Number](https://oracleofbacon.org/onecenter.php?who=Kevin+Bacon) as follows: ((0\*1)+(1\*3018)+(2\*349861)+(3\*1231256)+(4\*306009)+(5\*24753)+(6\*2963)+(7\*360)+(8\*32)+(9\*16)+(10\*2))/1+3018+349861+1231256+306009+24753+2963+360+32+16+2) = 5765027 / 1918271 = 3.006  **So the average** [**Bacon Number**](https://oracleofbacon.org/onecenter.php?who=Kevin+Bacon) **for Kevin Bacon is 3.00**6. |
| 0 | 1 |
| 1 | 3018 |
| 2 | 349861 |
| 3 | 1231256 |
| 4 | 306009 |
| 5 | 24753 |
| 6 | 2963 |
| 7 | 360 |
| 8 | 32 |
| 9 | 16 |
| 10 | 2 |

The Oracle of Bacon website also computes the average Bacon Number for each actor in our network. The lower an actor’s Bacon Number, the more connected he is in the movie industry. The Bacon Numbers for each of the actors in our network is shown below.

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| **Actor** | **Bacon Number** | bacon bacon everywhere - bacon bacon everywhere  Toy Story Everywhere**So, even in our little network, four of the actors have lower “Bacon Numbers” then KB himself!** |
| **Kevin Bacon** | **3.006** |
| **Tom Cruise** | **2.971** |
| **Ashley Judd** | **3.073** |
| **Tom Hanks** | **2.966** |
| **Bruce Willis** | **2.892** |
| **Renee Zellweger** | **3.077** |
| **Elijah Wood** | **3.005** |
| **Marisa Tomei** | **3.011** |

**Problem Set**

1. Construct a complete **Kevin Bacon co-star graph** (include the movie names as the edges in the Vertex/Edge Table below) for the following actors (vertices).

***Kevin Bacon, Morgan Freeman, George Clooney, Cameron Diaz, Will Ferrell, Scarlett Johansson, Eddie Redmayne***

 Include not only the direct and indirect actor links to Kevin Bacon but all other direct links among the actors in your graph. Remember that you are trying to find the ***shortest links*** between the actors and Kevin Bacon and all other actors in your graph. Use 2-letter initial sets to designate the vertices/actors—KB/BM/etc.

Use **The Oracle of Bacon** website ***{www.oracleofbacon.org}*** to create your graph but remember that there can be many links between actors. Do not accept the first link between any actor and Kevin Bacon. Check to see if you can find another link (if it is not direct) with a more famous actor as an intermediary. And always remember, neatness counts.

You must use the **Graph Creator** (<http://illuminations.nctm.org/Activity.aspx?id=3550>) to construct your finished graph. Since this program only allows you to label nodes as A, B, C, etc., you should very neatly write in the initials of the actors next to each node. Use the graph grid icon to make your graph as neat as possible—straight lines, no lines crossing, etc.



**Kevin Bacon Co-Star Graph**

2. Complete the **Shortest Paths Table** below and calculate the Degree Centrality and Closeness Centrality for each actor.

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|  | **Shortest Paths Between Actors** |  |  |  |  |
| **Actor** | **KB** |  |  |  |  |  |  |  |  |  |  |  |  |  | **Sum of Shortest Paths** | **# of 1-Links** | **Degree****Centrality** | **Closeness Centrality** |
| **KB** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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2. Complete the **Vertex/Edge Table** below for all of the actors in your graph.

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| **Actor #1** | **Actor #2** | **Movie (Edge)** |
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3. Find the **Bacon Numbers** for each of the actors in your network.

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| **Actor** | **Bacon Number** |
| Kevin Bacon | 3.006 |
| Morgan Freeman |  |
| George Clooney |  |
| Cameron Diaz |  |
| Will Ferrell |  |
| John Lithgow |  |
| Scarlett Johansson |  |
| Eddie Redmayne |  |
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4. Use the ***Oracle of Bacon*** to find two actors with Bacon Numbers of 3 or more. Make sure to identify the links as shown on the ***Oracle***site. Bonus points if you can find actors with Bacon numbers greater than 3. (Hint: Think old time movies and use the **IMDB** website (imdb.com) to help you or actors with similar names to the ones in your network.))

5. Using your favorite actor/actress as the center (he/she would have a **Bacon Number = 0**), construct a complete co-graph of at least 7 actors ***other than the ones above***. No more than 3 of the actors can have Bacon Numbers of 1, Miley Cyrus must be one of the actors in your network and you cannot link more than one actor in any movie to your center. **Mr. Cashill must approve your list before you start**.

**Your favorite actor: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Other Actors in your Network:**

**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Your Favorite Actor Co-Star Graph**

6. Complete the **Shortest Paths Table** below and calculate the Degree Centrality and Closeness Centrality for each actor.

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|  | **Shortest Paths Between Actors** |  |  |  |  |
| **Actor** |  |  |  |  |  |  |  |  |  |  |  |  |  |  | **Sum of Shortest Paths** | **# of 1-Links** | **Degree****Centrality** | **Closeness Centrality** |
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7. Complete the **Vertex/Edge Table** below for all of the actors in your graph.

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| **Actor #1** | **Actor #2** | **Movie (Edge)** |
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8. Find the Bacon Numbers for each of the actors in your network.

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| **Actor** | **Bacon Number** |
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**VHS Co-Star Graphs**

9. You are now going to become the star of your own network. Using yourself as the center, construct a graph of at least 8 other VHS students and teachers. You will have a Bacon (Peterson/Drozdowski/Baldwin/Kresta) Number of 0. A student/teacher in a class, on a sports team, in a club or related to you has a Bacon Number of 1. A student/teacher in a class, club or team with another student who has a Bacon number of 1 has a Bacon number of 2, etc.

 Your graph must meet the following parameters:

* At least one student/teacher having a Bacon Number of 3 or more.
* At least 1 teacher but no more than 2.
* No more than 3 students/teachers with Bacon Numbers of 1.
* The students/teachers with Bacon Numbers of 1 must be in different classes, clubs or teams.
* At least one student each must be from the freshman, sophomore, junior and senior classes.

Use the following page to construct your graph. Once you have identified the students and teachers in your network and have drawn a draft graph, you must find out the **direct connections**, if any, among all of the people in your network. For example, if you have Mr. Maher as a teacher and pick a freshman who also has Mr. Maher as a teacher, show that edge on your graph. Draw your graph on the next page.

Once you have the actors in your network, follow the same procedures that you did for the Kevin Bacon graphs by finding the shortest paths between your actors along with their Degree Centrality and Closeness Centrality.

10. Complete the **Shortest Paths Table** below and calculate the Degree Centrality and Closeness Centrality for each actor.

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|  | **Shortest Paths Between Actors** |  |  |  |  |
| **Actor** |  |  |  |  |  |  |  |  |  |  |  |  |  |  | **Sum of Shortest Paths** | **# of 1-Links** | **Degree****Centrality** | **Closeness Centrality** |
| **You** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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11. Complete the Vertex/Edge Table below for your network.

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| **Vertices** | **Edges** |
| **Student/Teacher #1** | **Student/Teacher #2** | **Class/Team/Club/Relation** |
| **You** |  |  |
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**Your VHS Co-Star Graph**

**VHS Discrete Math**

**Social Network Analysis**

**Six Degrees of Kevin Bacon**



 

**Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

*On my honor, I have neither given nor received any unacknowledged aid on this project.*

***Student Signature: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_***

* We will be going to the LMC for 2 days only; any other Internet or other work must be done on your own time. You are free to work at home, during lunch, in study, after school, etc.
* Your movie star center and the actors in your network must be different from all other students in the class.
* Actor graphs that have the same or very similar actors and movies in more than one packet will be considered as academic dishonesty.
* Work is due by the close of school on Monday, March 9th.