

Modular Vehicle Design Concept

Timothy J. Rue

Thesis submitted to the Faculty of the
Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of

Master of Science
in
Engineering Mechanics

Alfred L. Wicks, Chair
Scott W. Case
Mark S. Cramer

November 18, 2014
Blacksburg, Virginia

Keywords: Hybrid-Electric Vehicle, Autonomy, Wheel Hub Motors, Vehicle Concept, Logistics Demand Reduction, Expeditionary Power, Silent Operation, Batteries, Solid Oxide Fuel Cells, Structural Health Monitoring, Energy Harvesting Shock Absorbers, Non-pneumatic Tires, Protection from Electromagnetic Pulses, Drive by Wire, ITV, Vehicle Bounds, Mean Maximum Pressure, Advanced Mobility, M29 Weasel, TPz Fuchs, Jeep, Polaris

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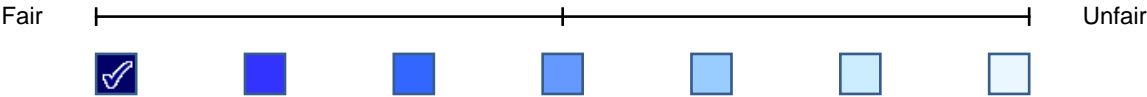
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| | |
|------------------------------|---|
| Name: | Timothy Rue |
| Job Title: | Research Assitant |
| Institution: | Virginia Tech |
| Title of Work Used: | 2 DOF diagram |
| Copyright Holder: | Anderson, Martyn Harty, Damian |
| Publication Status: | Published |
| Publisher: | 10th International Symposium on Advanced Vehicle ... |
| Place of Publication: | Online |
| Publication Year: | 2010 |
| Description of Work: | A diagram showing a two degree of freedom SMD system. |
| Date of Evaluation: | December 1, 2014 |
| Date of Intended Use: | December 1, 2014 |

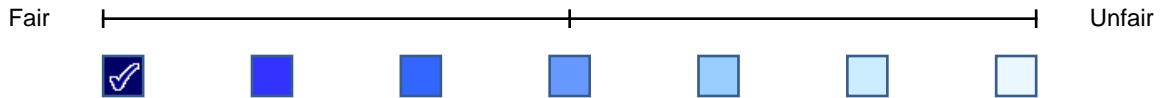
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[+] Use is one-time, or is only occasional or spontaneous



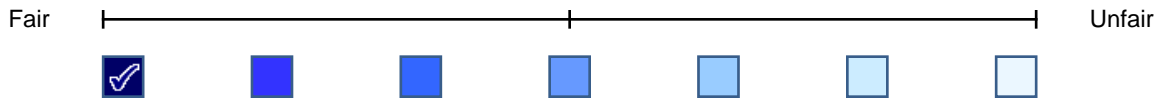
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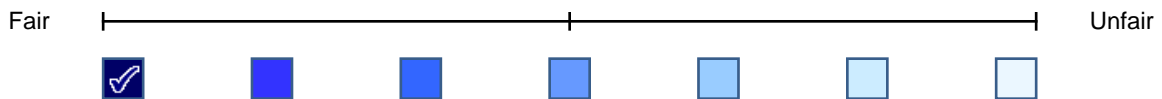
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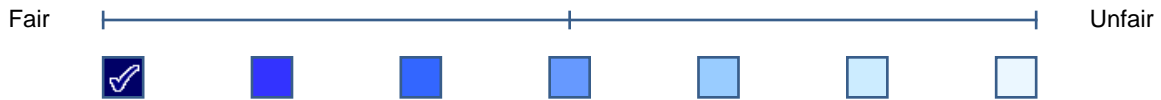
[+] The work is NOT currently under commercial exploitation (out of print, no licensing available, etc.)



The Average **"Fairness Level,"** Based on Your Rating of Each of the 4

Factors, Is:

[\[see tool disclaimer for important clarifying information\]:](#)



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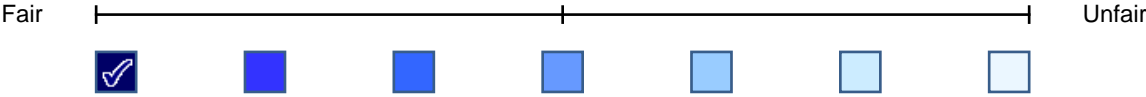
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|------------------------------|---------------------|
| Name: | Timothy Rue |
| Job Title: | Research Assitant |
| Institution: | Virginia Tech |
| Title of Work Used: | Activolve |
| Copyright Holder: | Levant Power |
| Publication Status: | Published |
| Publisher: | Levant Power |
| Place of Publication: | Online |
| Publication Year: | 2014 |
| Description of Work: | Activolve on shock. |
| Date of Evaluation: | December 1, 2014 |
| Date of Intended Use: | December 1, 2014 |

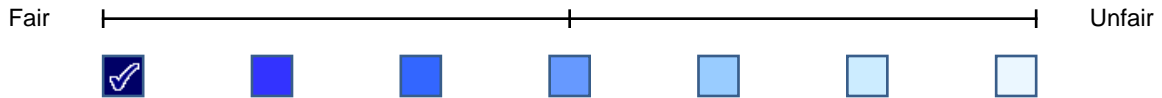
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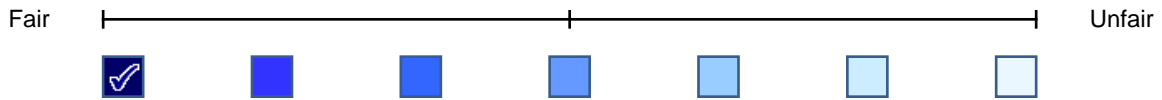
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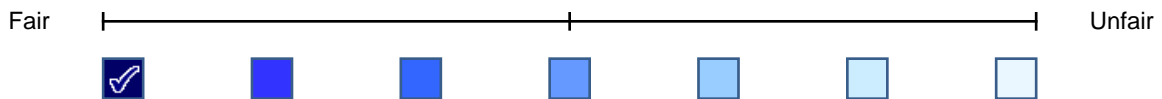
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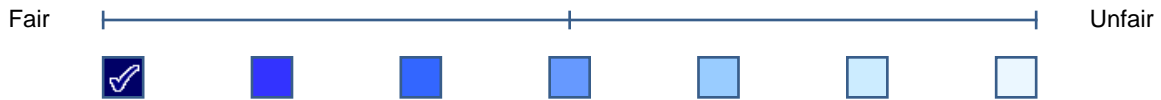
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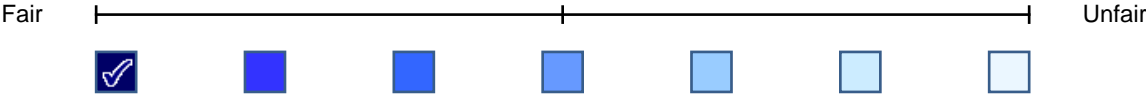
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| Name: | Timothy Rue |
| Job Title: | Research Assitant |
| Institution: | Virginia Tech |
| Title of Work Used: | British SAS on a Jeep |
| Copyright Holder: | David Stubblebine |
| Publication Status: | Published |
| Publisher: | World War Two Database |
| Place of Publication: | Online |
| Publication Year: | 2014 |
| Description of Work: | British SAS on a jeep in north Africa during WWII. |
| Date of Evaluation: | December 1, 2014 |
| Date of Intended Use: | December 1, 2014 |

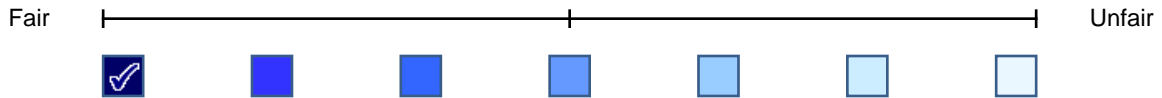
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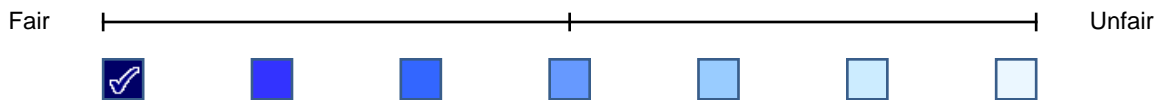
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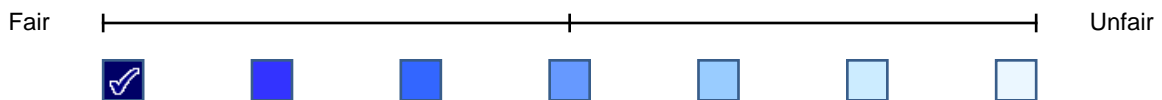
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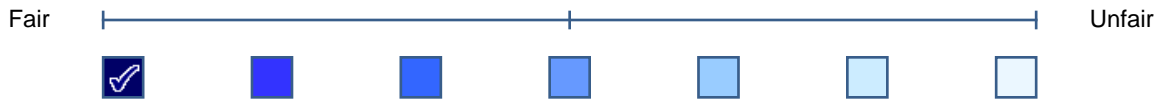
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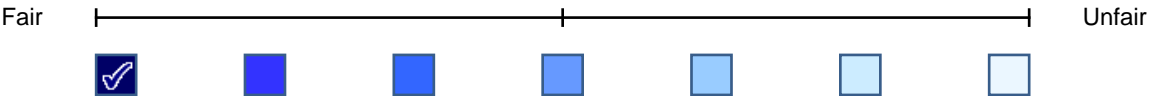
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| Name: | Timothy Rue |
| Job Title: | Research Assitant |
| Institution: | Virginia Tech |
| Title of Work Used: | Characteristics of Various Technologies/Types of batteries for use in vehicle applications |
| Copyright Holder: | Burke, Andrew F. |
| Publication Status: | Published |
| Publisher: | Proceedings of IEEE |
| Place of Publication: | Online |
| Publication Year: | 2007 |
| Description of Work: | A table comparing batteries for vehicle applications. |
| Date of Evaluation: | December 1, 2014 |
| Date of Intended Use: | December 1, 2014 |

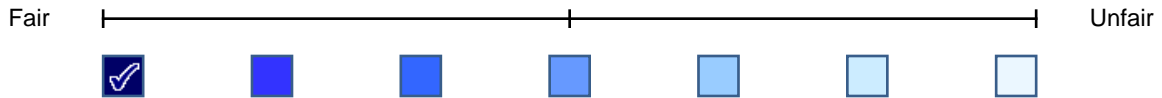
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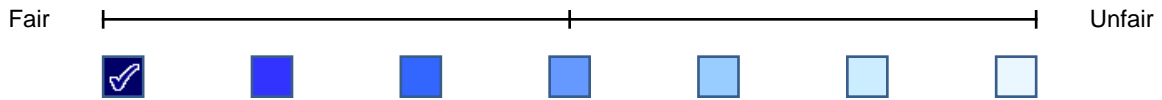
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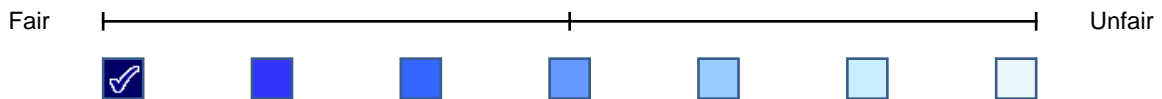
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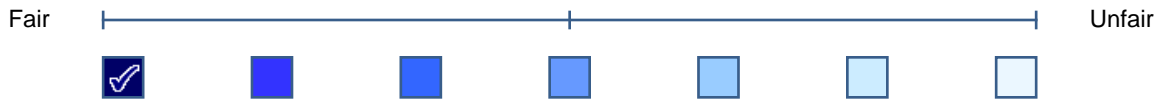
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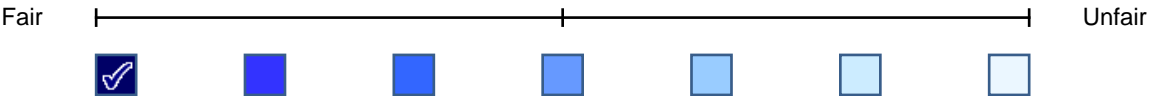
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| Name: | Timothy Rue |
| Job Title: | Research Assitant |
| Institution: | Virginia Tech |
| Title of Work Used: | Comparison performance between existing battery type |
| Copyright Holder: | Sutopo, W. Maryanie, D. I. Purwanto, A. Nizam, M. |
| Publication Status: | Published |
| Publisher: | 2013 Joint International Conference on Rural Information & Communication Technology and Electric-Vehicle Technology (rICT & ICeV-T) |
| Place of Publication: | Online |
| Publication Year: | 2013 |
| Description of Work: | A table showing the comparison of different battery types |
| Date of Evaluation: | December 1, 2014 |
| Date of Intended Use: | December 1, 2014 |

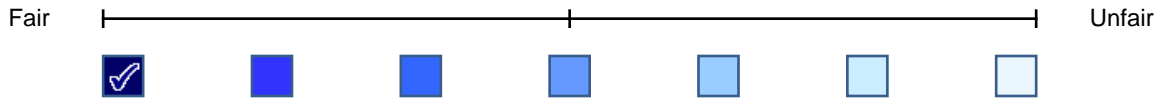
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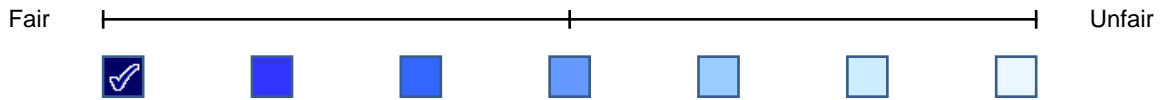
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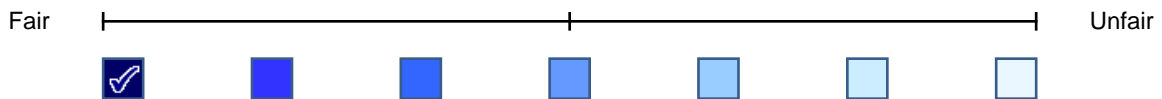
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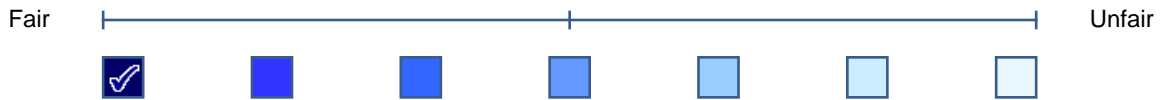
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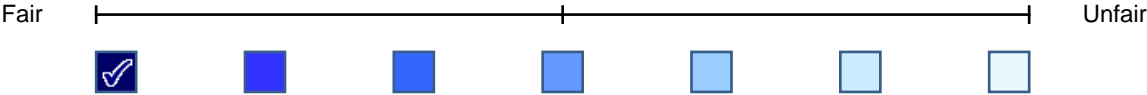
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|------------------------------|---|
| Name: | Timothy Rue |
| Job Title: | Research Assitant |
| Institution: | Virginia Tech |
| Title of Work Used: | DIDS System Concept |
| Copyright Holder: | Richards, W Lance Madaras, Eric Prosser, William H Studor, George |
| Publication Status: | Published |
| Publisher: | NASA |
| Place of Publication: | Online |
| Publication Year: | 2013 |
| Description of Work: | Accelerometers triangulating position of impact |
| Date of Evaluation: | December 1, 2014 |
| Date of Intended Use: | December 1, 2014 |

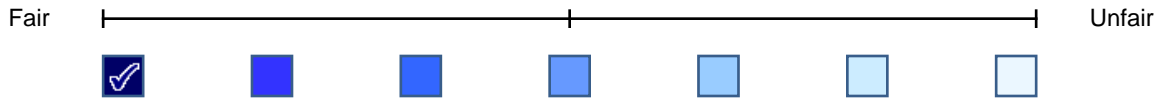
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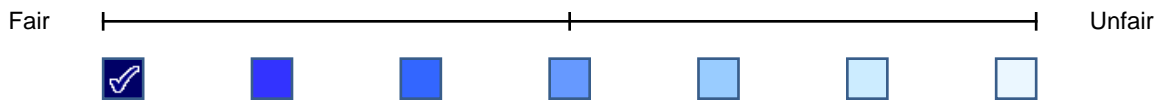
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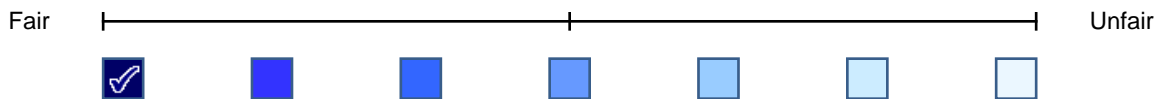
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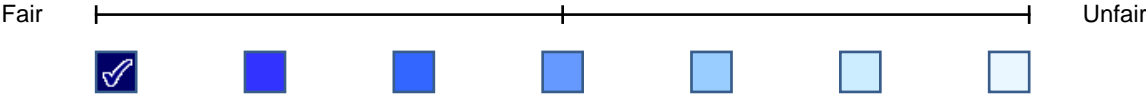
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|------------------------------|--|
| Name: | Timothy Rue |
| Job Title: | Research Assitant |
| Institution: | Virginia Tech |
| Title of Work Used: | Efficiency for WHM |
| Copyright Holder: | Freitag, Gunter Klopzig, Markus Schleicher, Klaus Wilke, Markus Schramm, Marco |
| Publication Status: | Published |
| Publisher: | IEEE |
| Place of Publication: | Online |
| Publication Year: | 2013 |
| Description of Work: | A diagram showing the efficiency lines of a wheel hub motor. |
| Date of Evaluation: | December 1, 2014 |
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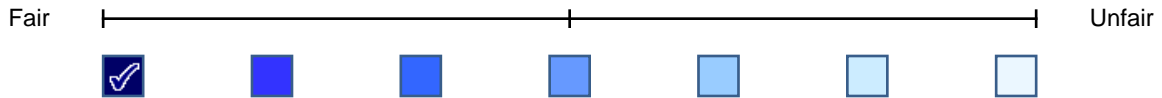
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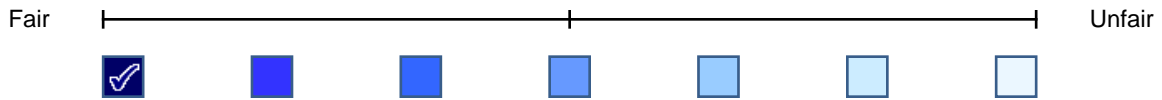
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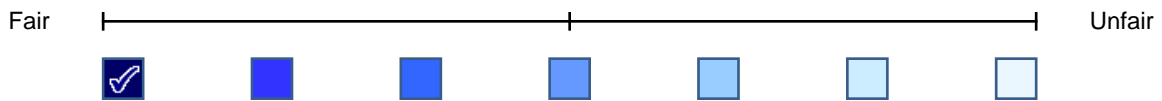
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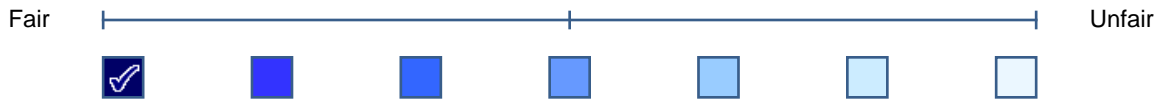
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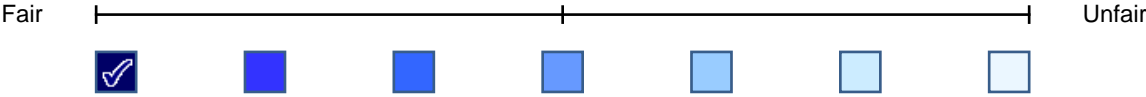
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|------------------------------|----------------------|
| Name: | Timothy Rue |
| Job Title: | Research Assitant |
| Institution: | Virginia Tech |
| Title of Work Used: | Google Car |
| Copyright Holder: | Darrell Etherington |
| Publication Status: | Published |
| Publisher: | Tech Crunch |
| Place of Publication: | Online |
| Publication Year: | 2014 |
| Description of Work: | The Oshkosh Terramax |
| Date of Evaluation: | December 1, 2014 |
| Date of Intended Use: | December 1, 2014 |

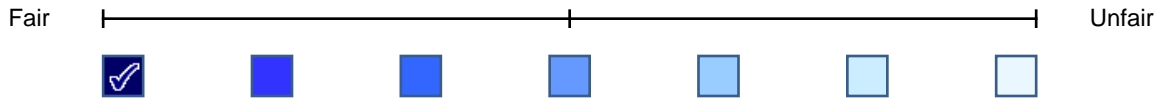
Describe the **Purpose** and Character of Your Intended Use:

[+] Use is for "criticism, comment, news reporting, teaching, (including multiple print copies for classroom use), scholarship or research"
[+] Use is not-for-profit
[+] Use is clearly defined and is restricted in scope (limited duration, not iterative, restricted access, etc.)
[+] Use is one-time, or is only occasional or spontaneous



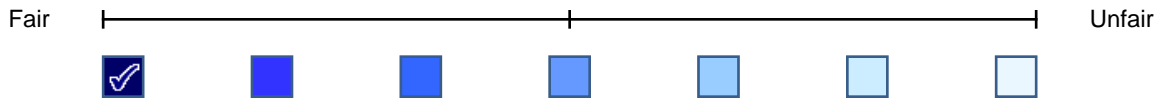
Describe the **Nature** of Your Intended Use of the Copyrighted Work:

[+] Work to be used has been previously PUBLISHED
[+] Work to be used contains limited new knowledge, content, or creative expression (in relation to previously copyrighted works)
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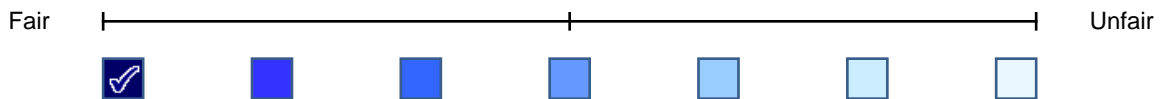
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Describe the **Effect** of Your Intended Use on the Potential Market or Value of the Copyrighted Work:

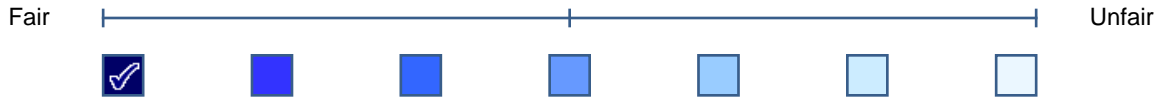
[+] The work is NOT currently under commercial exploitation (out of print, no licensing available, etc.)



The Average **"Fairness Level,"** Based on Your Rating of Each of the 4

Factors, Is:

[\[see tool disclaimer for important clarifying information\]:](#)



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Date of Signature: _____

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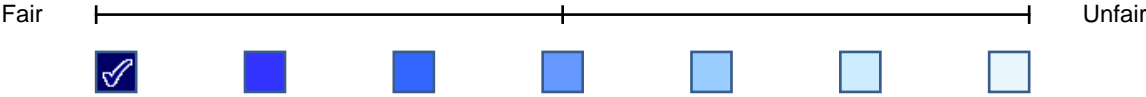
Fair Use Evaluation Documentation

Compiled using the **Fair Use Evaluator** [cc] 2008 Michael Brewer & the Office for Information Technology Policy, <http://librarycopyright.net/fairuse/>

| | |
|------------------------------|---|
| Name: | Timothy Rue |
| Job Title: | Research Assitant |
| Institution: | Virginia Tech |
| Title of Work Used: | Integrated Design Procedures for system reliability |
| Copyright Holder: | Isermann, R. Schwarz, R. Stolzl, S. |
| Publication Status: | Published |
| Publisher: | IEEE Control Systems Magazine |
| Place of Publication: | Online |
| Publication Year: | 2002 |
| Description of Work: | Flow chart for achieving system reliability |
| Date of Evaluation: | December 1, 2014 |
| Date of Intended Use: | December 1, 2014 |

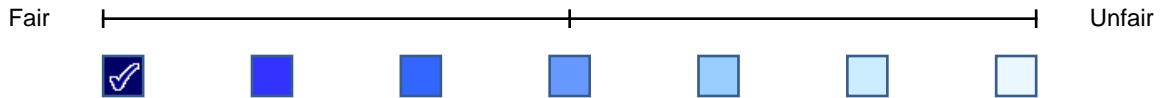
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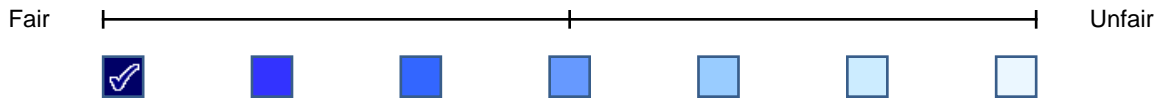
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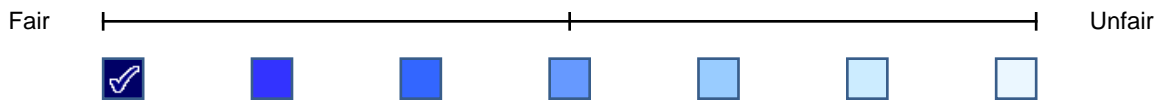
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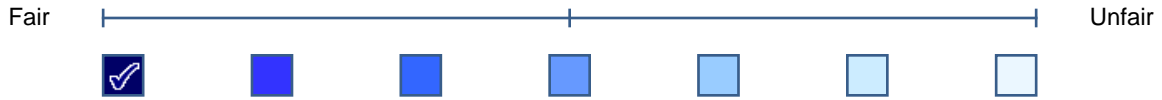
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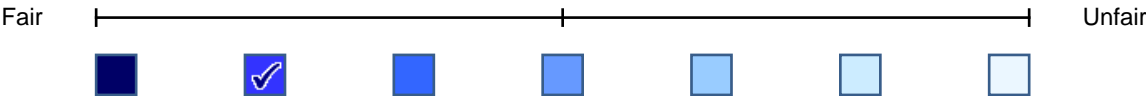
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| | |
|------------------------------|--|
| Name: | Timothy Rue |
| Job Title: | Research Assitant |
| Institution: | Virginia Tech |
| Title of Work Used: | Internal workings of a wheel hub motor |
| Copyright Holder: | Ifedi, Chukwuma J. Mecrow, Barrie C. Brockway, Simon T. M. Boast, Gerard S. Atkinson, Glynn J. Kostic-Perovic, Dragica |
| Publication Status: | Published |
| Publisher: | IEEE |
| Place of Publication: | Online |
| Publication Year: | 2013 |
| Description of Work: | A diagram showing the internal workings of a wheel hub motor. |
| Date of Evaluation: | December 1, 2014 |
| Date of Intended Use: | December 1, 2014 |

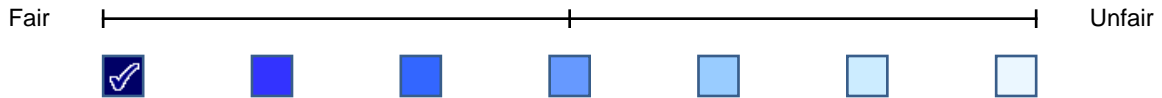
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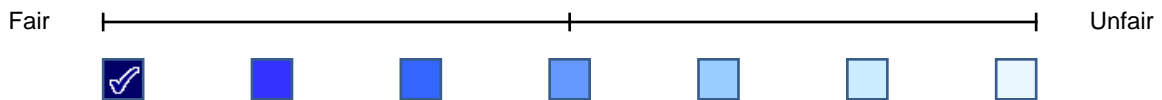
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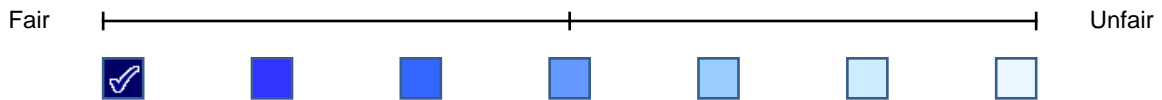
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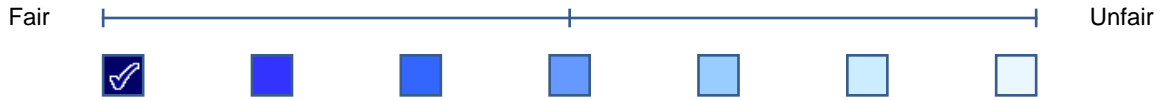
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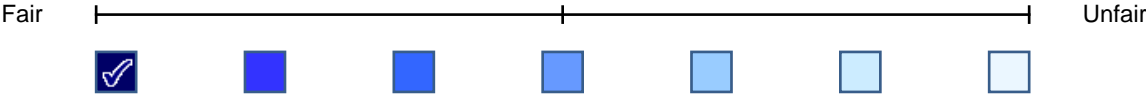
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| | |
|------------------------------|---|
| Name: | Timothy Rue |
| Job Title: | Research Assitant |
| Institution: | Virginia Tech |
| Title of Work Used: | Li-ion rechargeable battery |
| Copyright Holder: | Marshall Brian |
| Publication Status: | Published |
| Publisher: | How Stuff Works |
| Place of Publication: | Online |
| Publication Year: | 2013 |
| Description of Work: | A diagram showing the chemistry of a Li-ion battery |
| Date of Evaluation: | December 1, 2014 |
| Date of Intended Use: | December 1, 2014 |

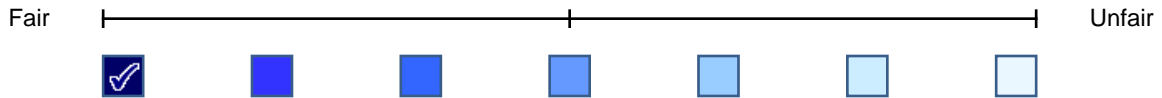
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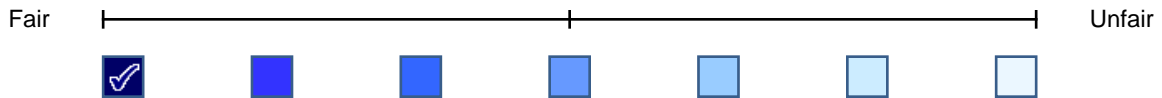
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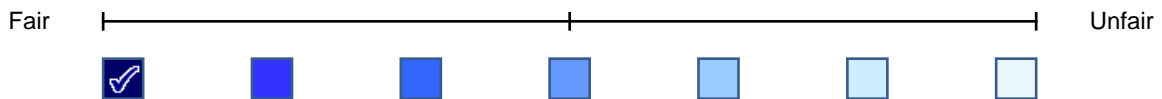
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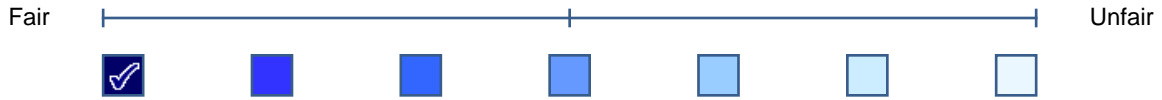
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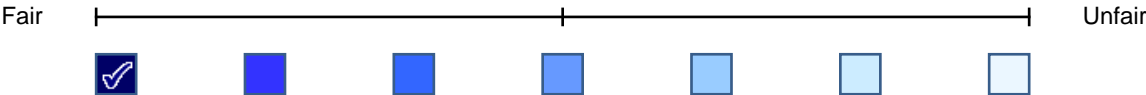
Fair Use Evaluation Documentation

Compiled using the **Fair Use Evaluator** [cc] 2008 Michael Brewer & the Office for Information Technology Policy, <http://librarycopyright.net/fairuse/>

| | |
|------------------------------|--|
| Name: | Timothy Rue |
| Job Title: | Research Assitant |
| Institution: | Virginia Tech |
| Title of Work Used: | M29 Weasel |
| Copyright Holder: | Margaret Bourke-White |
| Publication Status: | Published |
| Publisher: | Time |
| Place of Publication: | Magazine |
| Publication Year: | 1945 |
| Description of Work: | Us Fifth Army In Italy Amer. 10th Mountain Div. Army ski patrol, riding in a snow buggy, on the Italian front in the Apennine Mountains. |
| Date of Evaluation: | December 1, 2014 |
| Date of Intended Use: | December 1, 2014 |

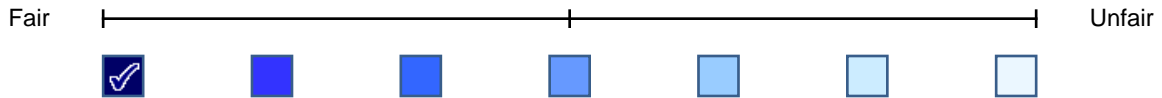
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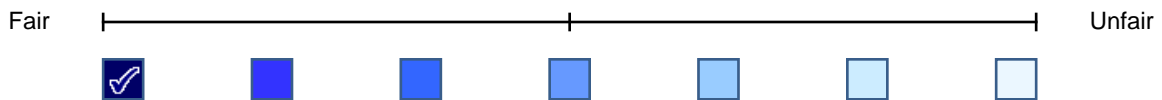
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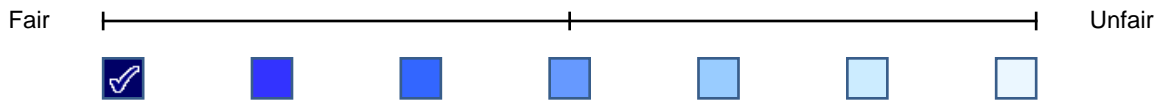
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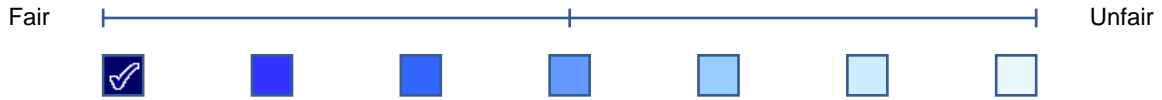
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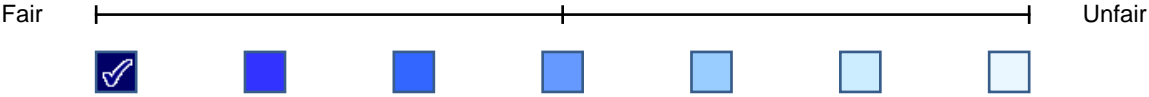
Fair Use Evaluation Documentation

Compiled using the **Fair Use Evaluator** [cc] 2008 Michael Brewer & the Office for Information Technology Policy, <http://librarycopyright.net/fairuse/>

| | |
|------------------------------|--|
| Name: | Timothy Rue |
| Job Title: | Research Assitant |
| Institution: | Virginia Tech |
| Title of Work Used: | Military Truck |
| Copyright Holder: | Guenter Hohl |
| Publication Status: | Published |
| Publisher: | Journal of Terramechanics |
| Place of Publication: | Online |
| Publication Year: | 2007 |
| Description of Work: | Diagram of the engine and drive train in a military truck. |
| Date of Evaluation: | December 1, 2014 |
| Date of Intended Use: | December 1, 2014 |

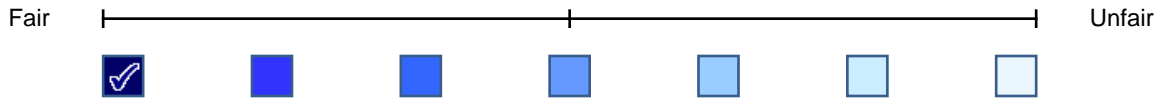
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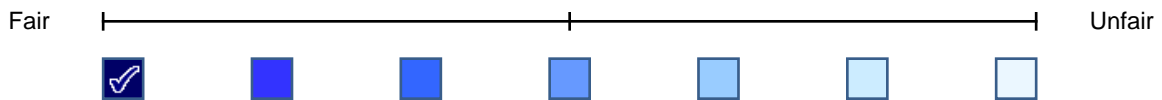
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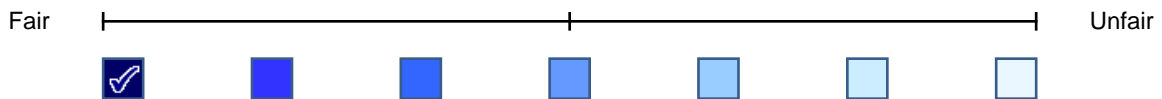
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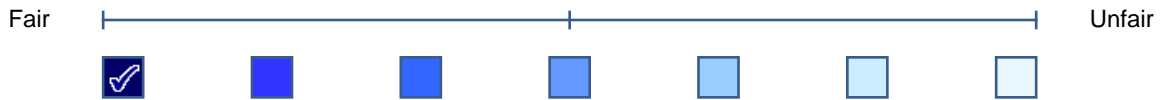
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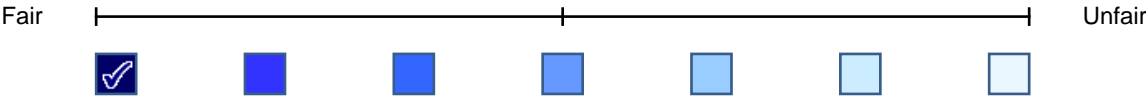
Fair Use Evaluation Documentation

Compiled using the **Fair Use Evaluator** [cc] 2008 Michael Brewer & the Office for Information Technology Policy, <http://librarycopyright.net/fairuse/>

| | |
|------------------------------|---------------------------------------|
| Name: | Timothy Rue |
| Job Title: | Research Assitant |
| Institution: | Virginia Tech |
| Title of Work Used: | MULE |
| Copyright Holder: | Defense Update |
| Publication Status: | Published |
| Publisher: | Defense Update |
| Place of Publication: | Online |
| Publication Year: | 2007 |
| Description of Work: | MULE showing shoulder joint mobility. |
| Date of Evaluation: | December 1, 2014 |
| Date of Intended Use: | December 1, 2014 |

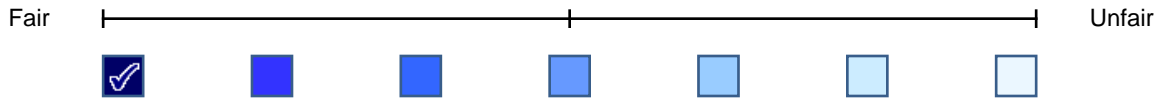
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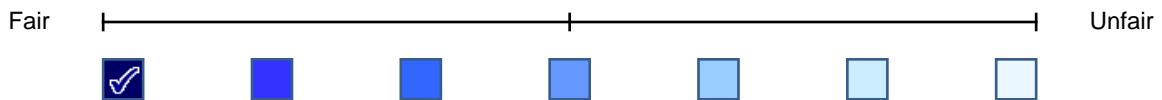
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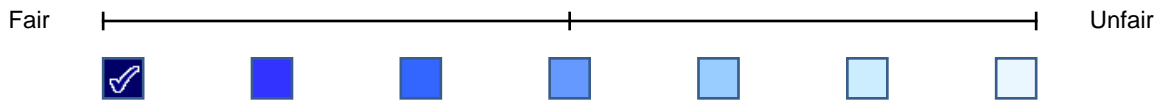
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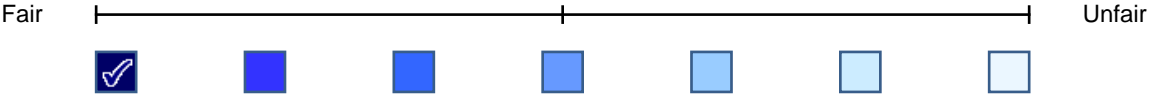
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| | |
|------------------------------|----------------------|
| Name: | Timothy Rue |
| Job Title: | Research Assitant |
| Institution: | Virginia Tech |
| Title of Work Used: | Oshkosh Terramax |
| Copyright Holder: | BBC |
| Publication Status: | Published |
| Publisher: | BBC |
| Place of Publication: | Online |
| Publication Year: | 2014 |
| Description of Work: | The Oshkosh Terramax |
| Date of Evaluation: | December 1, 2014 |
| Date of Intended Use: | December 1, 2014 |

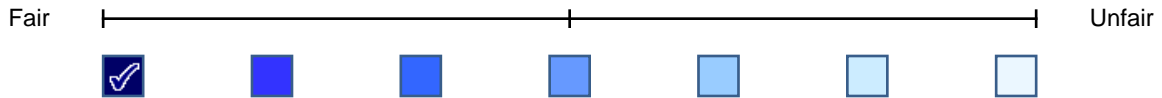
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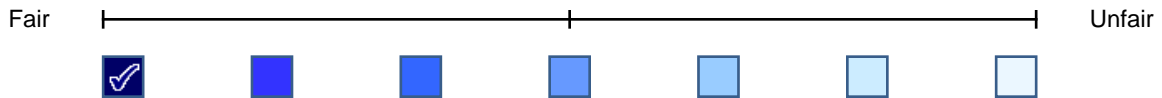
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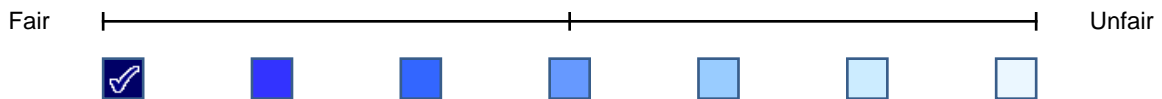
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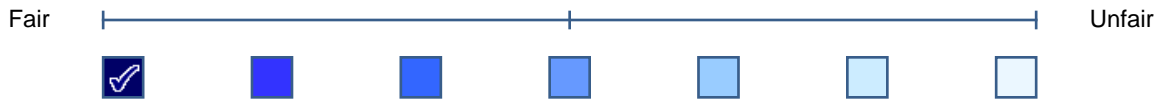
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Factors, Is:

[\[see tool disclaimer for important clarifying information\]:](#)



Based on the information and justification I have provided above, I, Timothy Rue, am asserting this use is **FAIR** under Section 107 of the U.S. Copyright Code.

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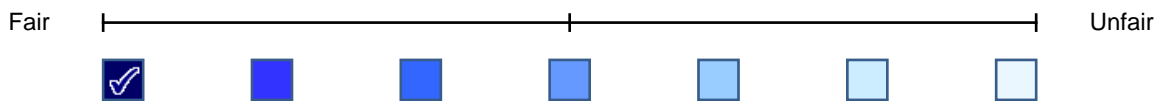
Fair Use Evaluation Documentation

Compiled using the **Fair Use Evaluator** [cc] 2008 Michael Brewer & the Office for Information Technology Policy, <http://librarycopyright.net/fairuse/>

| | |
|------------------------------|---|
| Name: | Timothy Rue |
| Job Title: | Research Assitant |
| Institution: | Virginia Tech |
| Title of Work Used: | Solid Oxide Fuel Cell |
| Copyright Holder: | Earnest Garrison |
| Publication Status: | Published |
| Publisher: | Earnest Garrison |
| Place of Publication: | Online |
| Publication Year: | 2014 |
| Description of Work: | A diagram of the chemistry behind SOFCs |
| Date of Evaluation: | December 1, 2014 |
| Date of Intended Use: | December 1, 2014 |

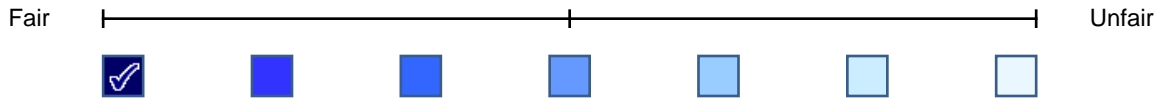
Describe the **Purpose** and Character of Your Intended Use:

[+] Use is for "criticism, comment, news reporting, teaching, (including multiple print copies for classroom use), scholarship or research"
[+] Use is not-for-profit
[+] Use is clearly defined and is restricted in scope (limited duration, not iterative, restricted access, etc.)
[+] Use is one-time, or is only occasional or spontaneous



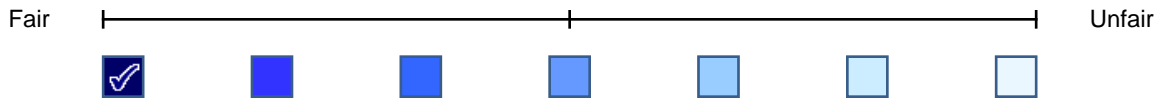
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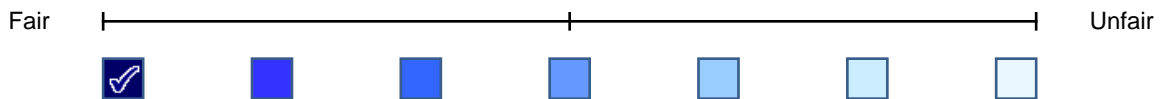
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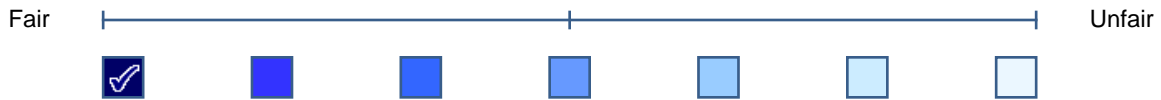
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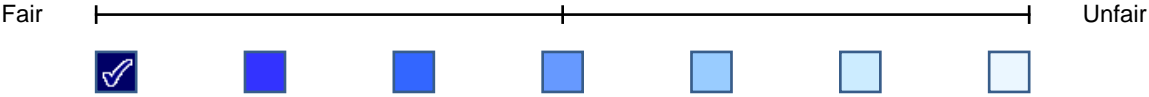
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| | |
|------------------------------|---|
| Name: | Timothy Rue |
| Job Title: | Research Assitant |
| Institution: | Virginia Tech |
| Title of Work Used: | Three-dimensional model and photo of the shock absorber prototype |
| Copyright Holder: | Li, Zhongjie Zuo, Lei Luhrs, George Lin, Liangjun Qin, Yi-xian |
| Publication Status: | Published |
| Publisher: | IEEE Transactions on Vehicular Technology |
| Place of Publication: | Online |
| Publication Year: | 2013 |
| Description of Work: | Activalue on shock. |
| Date of Evaluation: | December 1, 2014 |
| Date of Intended Use: | December 1, 2014 |

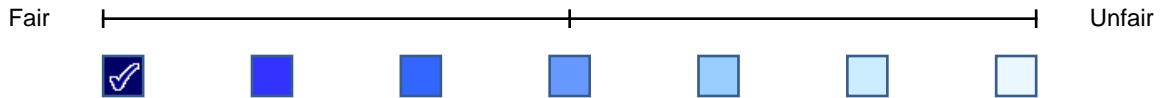
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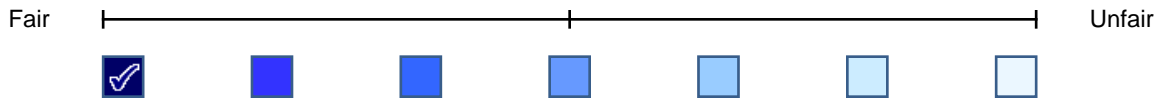
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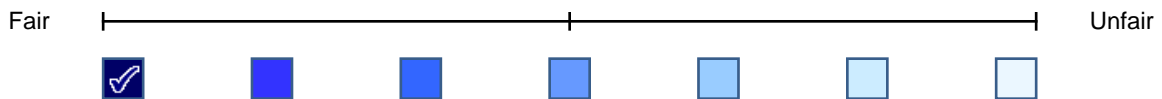
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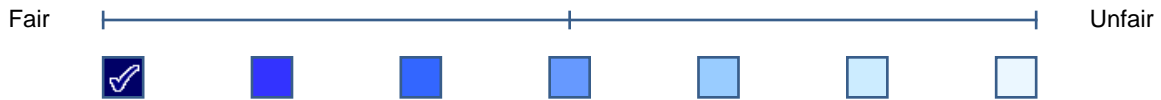
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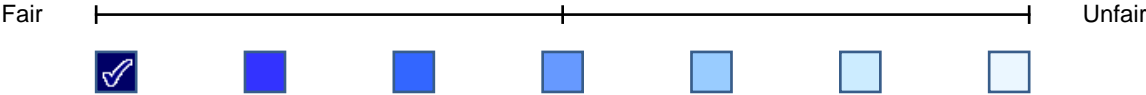
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| | |
|------------------------------|-------------------------|
| Name: | Timothy Rue |
| Job Title: | Research Assitant |
| Institution: | Virginia Tech |
| Title of Work Used: | TPz Fuchs |
| Copyright Holder: | Military Today |
| Publication Status: | Published |
| Publisher: | Military Today |
| Place of Publication: | Online |
| Publication Year: | 2014 |
| Description of Work: | TPz Fuchs in operation. |
| Date of Evaluation: | December 1, 2014 |
| Date of Intended Use: | December 1, 2014 |

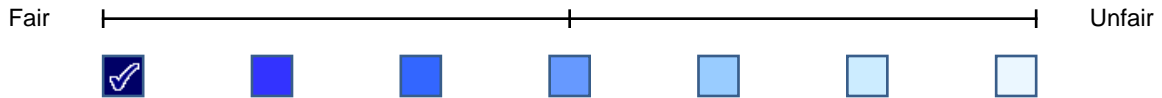
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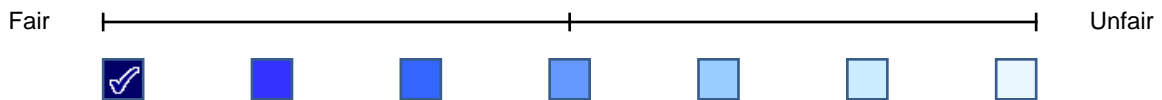
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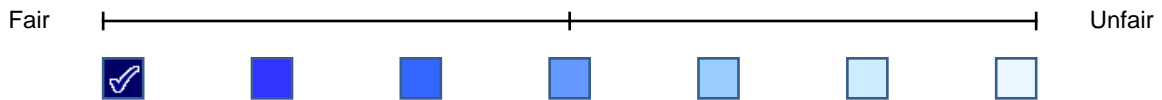
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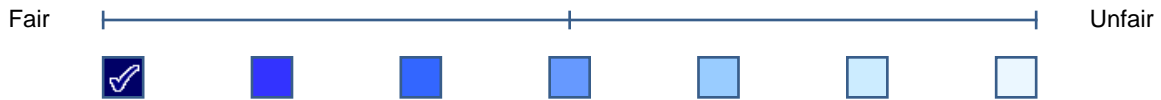
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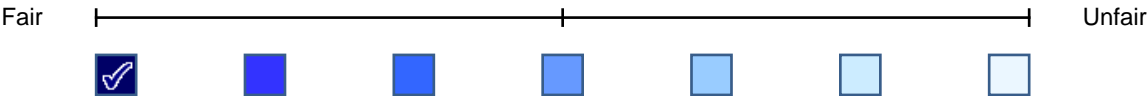
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| | |
|------------------------------|---|
| Name: | Timothy Rue |
| Job Title: | Research Assitant |
| Institution: | Virginia Tech |
| Title of Work Used: | Tradeoffs between lithium-ion battery technologies |
| Copyright Holder: | Sutopo, W. Maryanie, D. I. Purwanto, A. Nizam, M. |
| Publication Status: | Published |
| Publisher: | 2013 Joint International Conference on Rural Information & Communication Technology and Electric-Vehicle Technology (rICT & ICeV-T) |
| Place of Publication: | Online |
| Publication Year: | 2013 |
| Description of Work: | A diagram showing the comparison of different li-ion battery types |
| Date of Evaluation: | December 1, 2014 |
| Date of Intended Use: | December 1, 2014 |

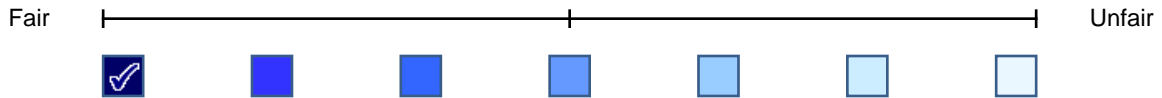
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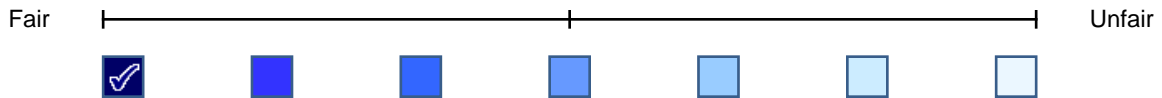
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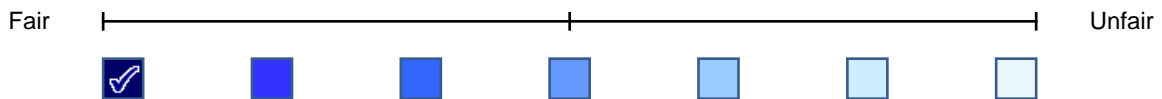
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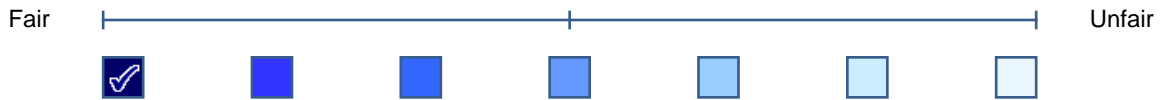
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