Ethical Issues at the Intersection of Engineering and Medicine

March 6, 2020

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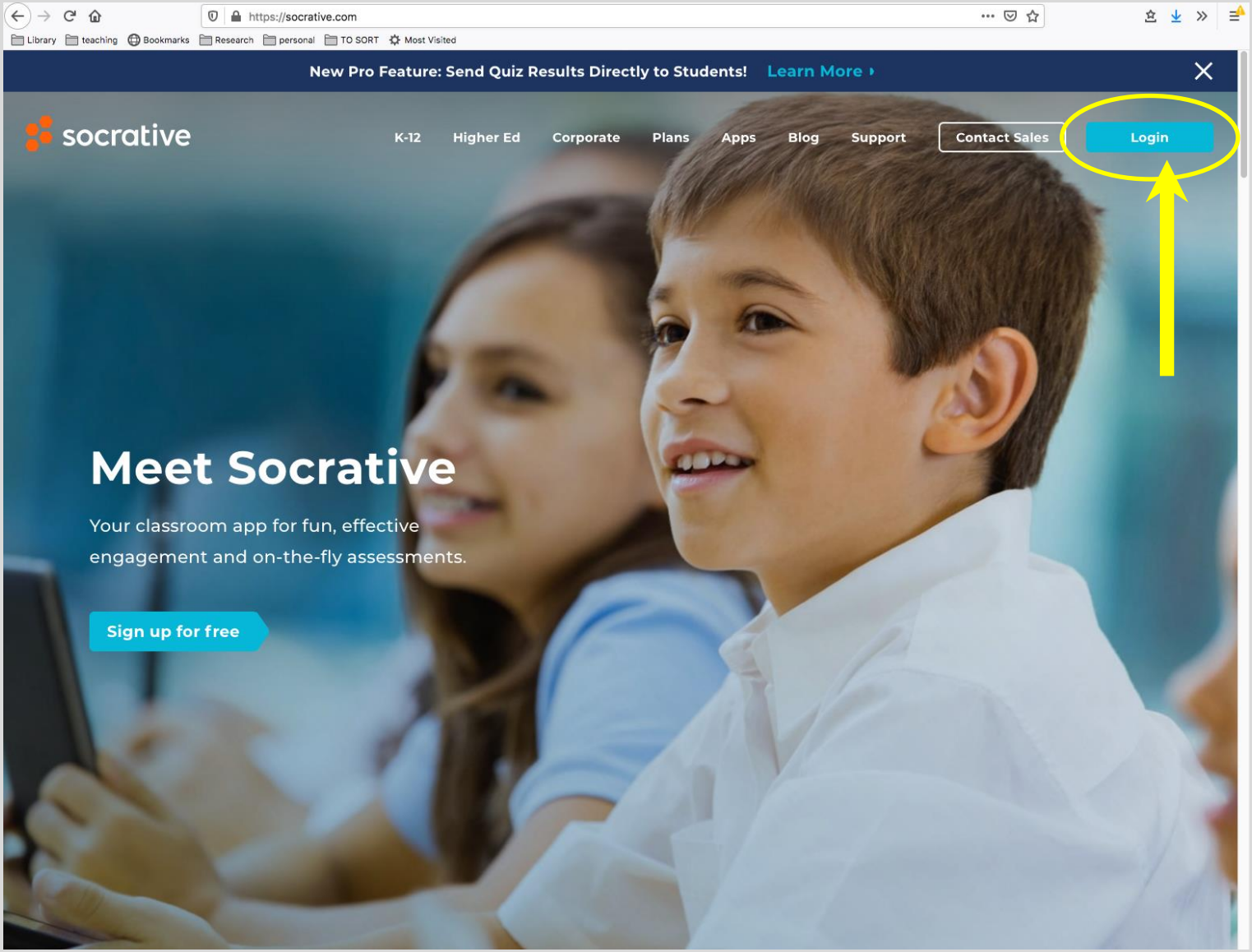
www.socrative.com



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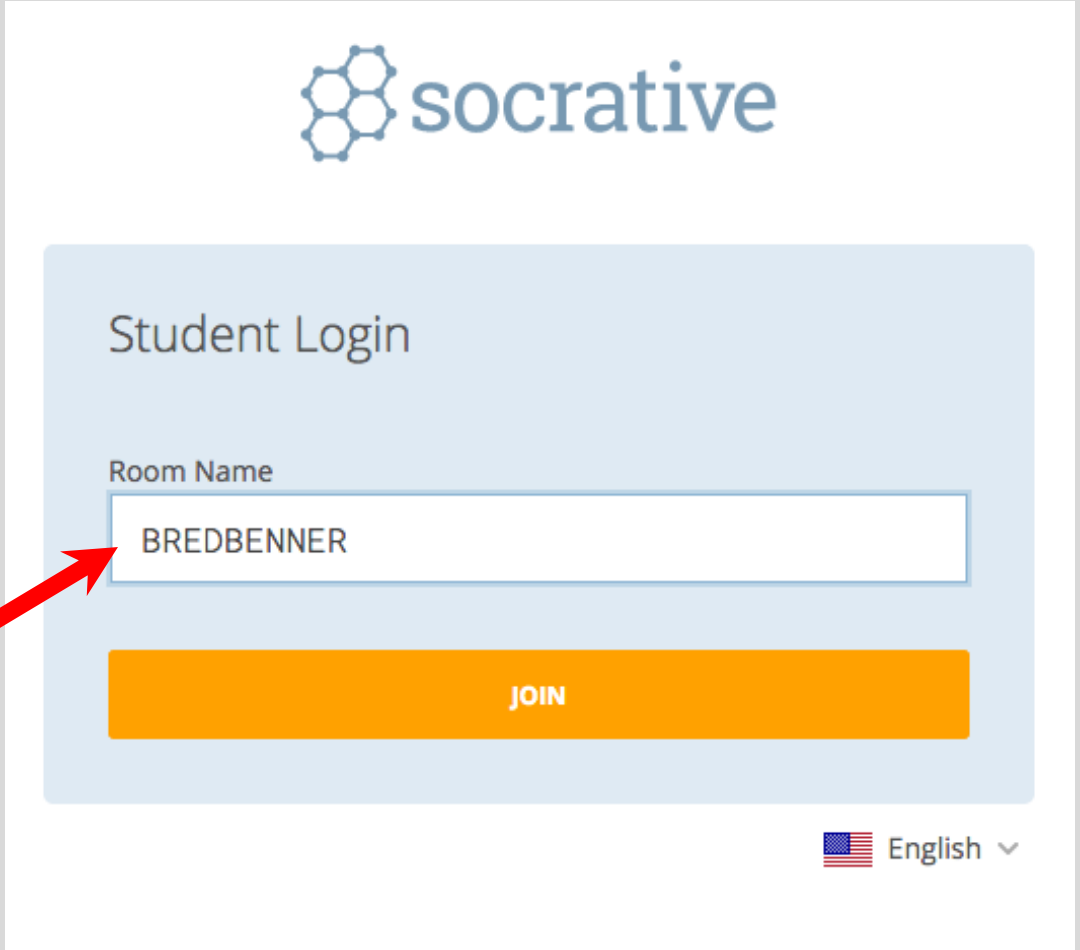
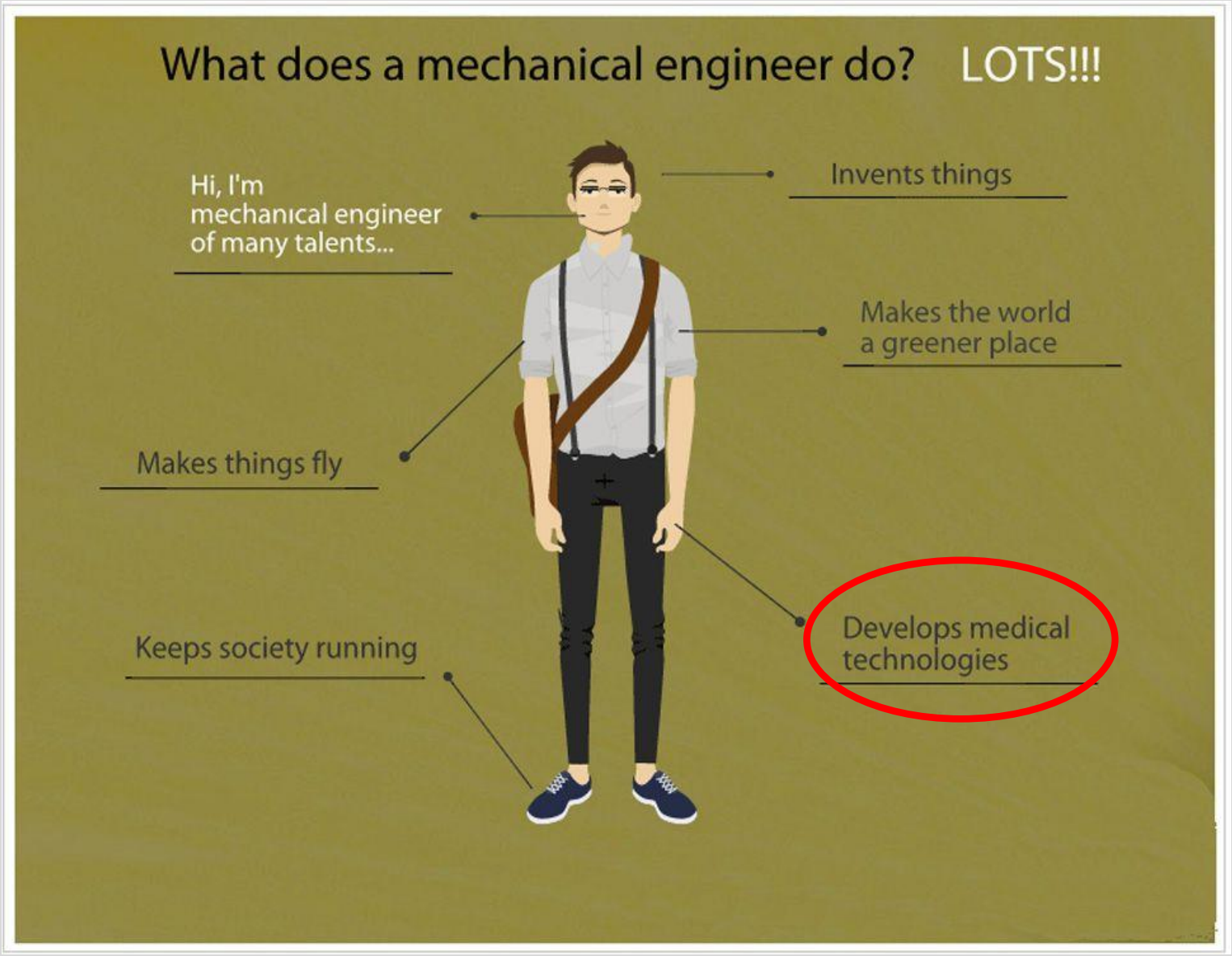
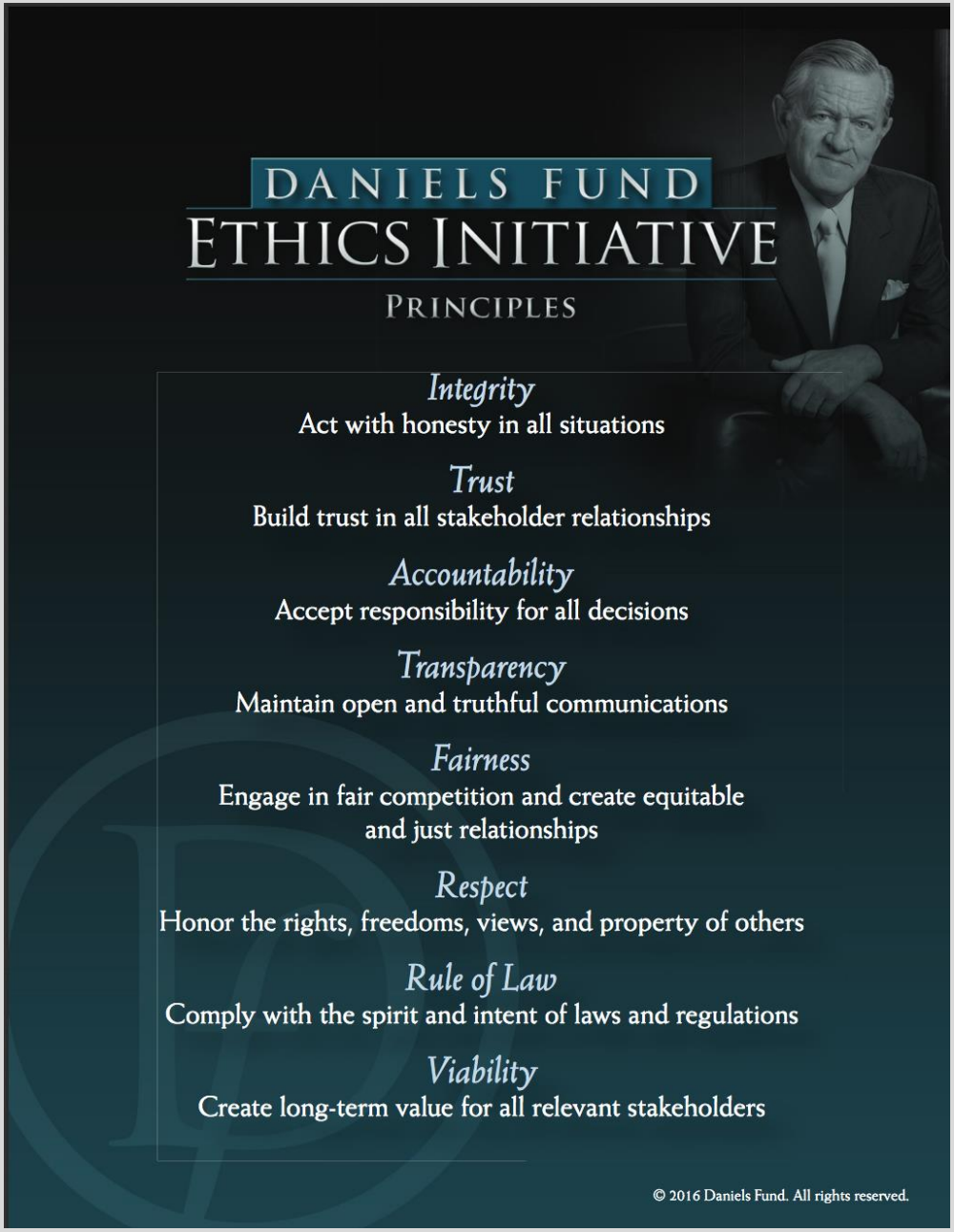


(teespring.com)

(20th Century Fox)



(Brindavan College)



(www.danielsfund.org)

Daniels Fund Ethics Initiative Principles

- *Integrity*
- *Trust*
- *Accountability*
- *Transparency*
- *Fairness*
- *Respect*
- *Rule of Law*
- *Viability*

ASME
SETTING THE STANDARD

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SOCIETY POLICY

ETHICS

ASME requires ethical practice by each of its members and has adopted the following Code of Ethics of Engineers as referenced in the ASME Constitution, Article C2.1.1.

CODE OF ETHICS OF ENGINEERS

The Fundamental Principles

Engineers uphold and advance the integrity, honor and dignity of the engineering profession by:

I. using their knowledge and skill for the enhancement of human welfare;

II. being honest and impartial, and serving with fidelity their clients (including their employers) and the public; and

III. striving to increase the competence and prestige of the engineering profession.

(American Society of Mechanical Engineers, 2012)

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The Fundamental Canons

1. Engineers shall hold paramount the safety, health and welfare of the public in the performance of their professional duties.
2. Engineers shall perform services only in the areas of their competence; they shall build their professional reputation on the merit of their services and shall not compete unfairly with others.
3. Engineers shall continue their professional development throughout their careers and shall provide opportunities for the professional and ethical development of those engineers under their supervision.
4. Engineers shall act in professional matters for each employer or client as faithful agents or trustees, and shall avoid conflicts of interest or the appearance of conflicts of interest.
5. Engineers shall respect the proprietary information and intellectual property rights of others, including charitable organizations and professional societies in the engineering field.
6. Engineers shall associate only with reputable persons or organizations.
7. Engineers shall issue public statements only in an objective and truthful manner and shall avoid any conduct which brings discredit upon the profession.
8. Engineers shall consider environmental impact and sustainable development in the performance of their professional duties.
9. Engineers shall not seek ethical sanction against another engineer unless there is good reason to do so under the relevant codes, policies and procedures governing that engineer's ethical conduct.
10. Engineers who are members of the Society shall endeavor to abide by the Constitution, By-Laws and Policies of the Society, and they shall disclose knowledge of any matter involving another member's alleged violation of this Code of Ethics or the Society's Conflicts of Interest Policy in a prompt, complete and truthful manner to the chair of the Ethics Committee.

(American Society of Mechanical Engineers, 2012)

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AMA CODE OF MEDICAL ETHICS

AMA PRINCIPLES OF MEDICAL ETHICS*

Preamble

The medical profession has long subscribed to a body of ethical statements developed primarily for the benefit of the patient. As a member of this profession, a physician must recognize responsibility to patients first and foremost, as well as to society, to other health professionals, and to self. The following Principles adopted by the American Medical Association are not laws, but standards of conduct that define the essentials of honorable behavior for the physician.

Principles of medical ethics

I. A physician shall be dedicated to providing competent medical care, with compassion and respect for human dignity and rights.

II. A physician shall uphold the standards of professionalism, be honest in all professional interactions, and strive to report physicians deficient in character or competence, or engaging in fraud or deception, to appropriate entities.

III. A physician shall respect the law and also recognize a responsibility to seek changes in those requirements which are contrary to the best interests of the patient.

IV. A physician shall respect the rights of patients, colleagues, and other health professionals, and shall safeguard patient confidences and privacy within the constraints of the law.

V. A physician shall continue to study, apply, and advance scientific knowledge, maintain a commitment to medical education, make relevant information available to patients, colleagues, and the public, obtain consultation, and use the talents of other health professionals when indicated.

VI. A physician shall, in the provision of appropriate patient care, except in emergencies, be free to choose whom to serve, with whom to associate, and the environment in which to provide medical care.

VII. A physician shall recognize a responsibility to participate in activities contributing to the improvement of the community and the betterment of public health.

VIII. A physician shall, while caring for a patient, regard responsibility to the patient as paramount.

IX. A physician shall support access to medical care for all people.

(American Medical Association, 2016)

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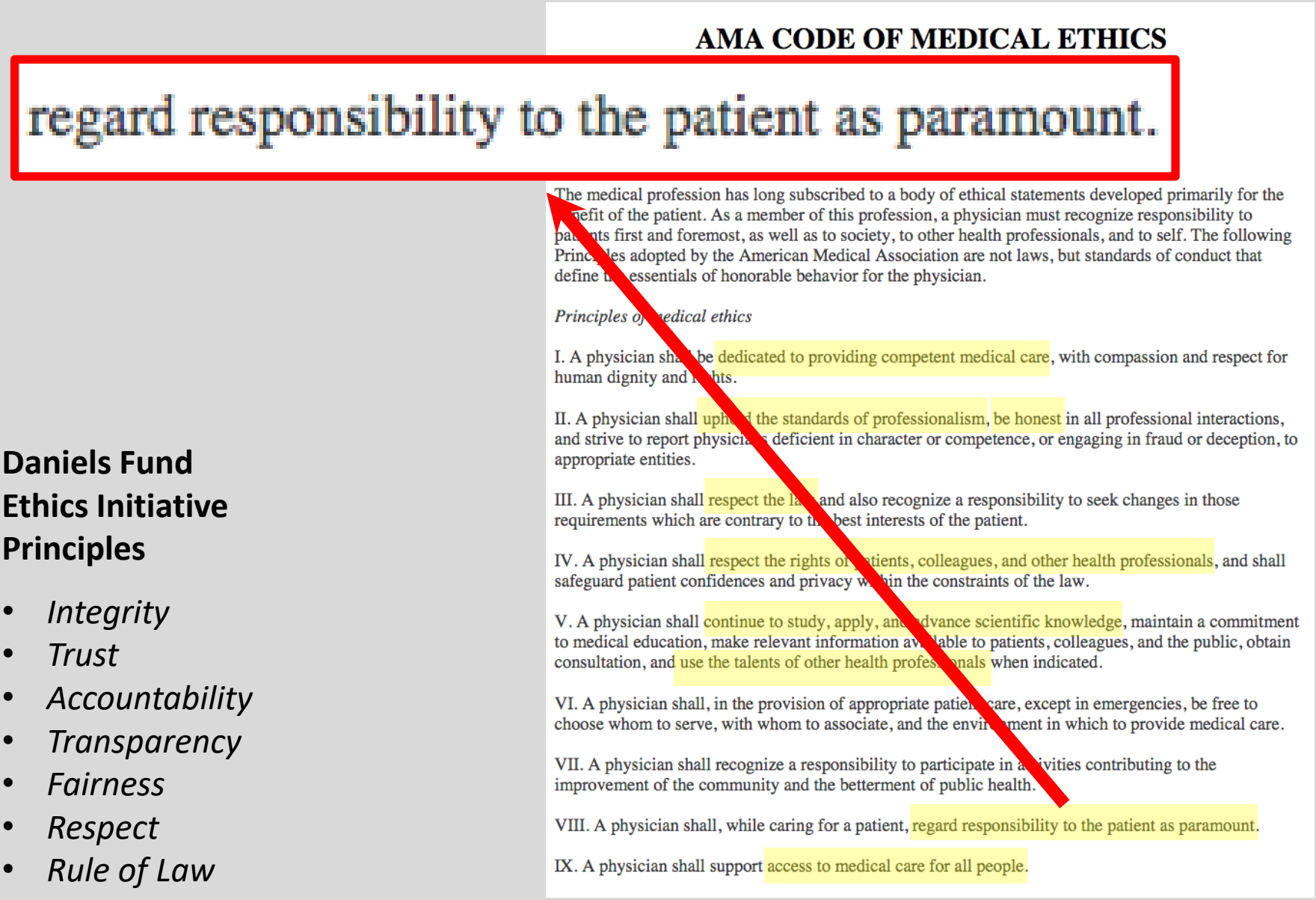

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(American Medical Association, 2016)

CODES OF ETHICS, BIOMECHANICS, AND CONFLICT OF INTEREST

First World Congress of Biomechanics
La Jolla, California
31 August 1990

Biomechanical engineers working in a hospital (or other medical enterprise) are certainly engineers. They employ much the same method, skills, and knowledge other engineers do; and, like other engineers, they are concerned with developing, installing, and operating safe and useful devices. They are, however, not ordinary engineers. Most engineers work in organizations where engineering is a central concern. Even in a finance-dominated company like General Motors, engineering is the mother tongue, the language of most of those with whom most engineers must deal.

(Michael Davis, Center for Study of Ethics in the Professions, Illinois Institute of Technology)

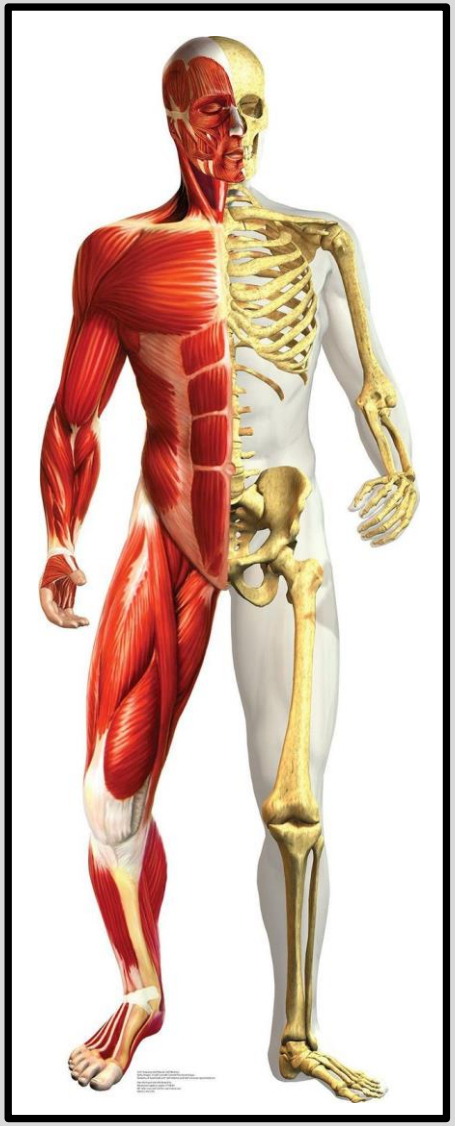
That, however, is not true of a hospital. Medicine is the mother tongue there. A biomechanical engineer working in a hospital may be the only engineer around. And even when he has a few colleagues, they will together form only a small part of the organization. Most of their dealings will be with physicians, nurses, medical administrators, and others to whom engineering is alien.

(Michael Davis, Center for Study of Ethics in the Professions, Illinois Institute of Technology)

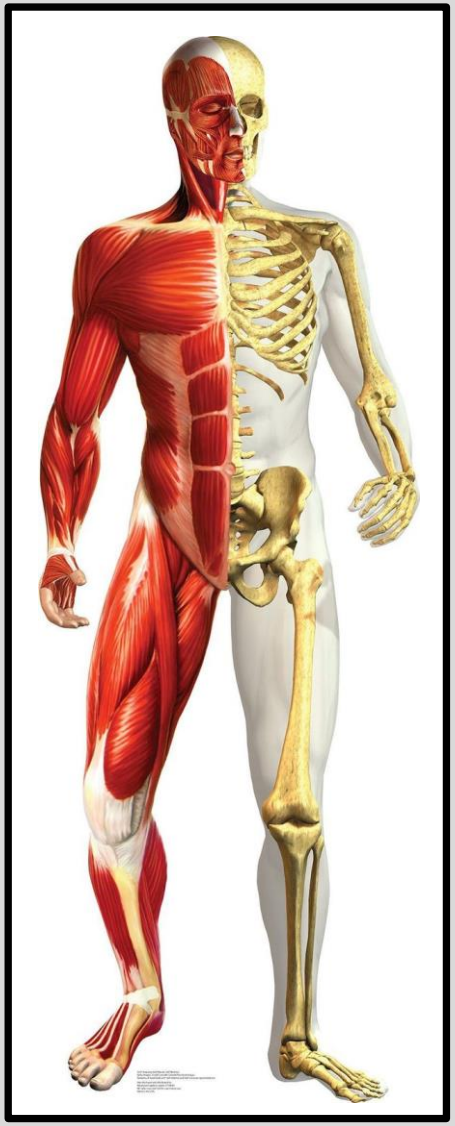
This alone suggests that the hospital may be an environment where ordinary engineering ethics is not appropriate. There are other reasons to think so. I will point out only one more here. Engineers generally agree that the safety, health, and welfare of the public comes first. Yet, for physicians, nurses, and other health care professionals, the safety, health, and welfare of the patient, not the public, is what comes first.

(Michael Davis, Center for Study of Ethics in the Professions, Illinois Institute of Technology)

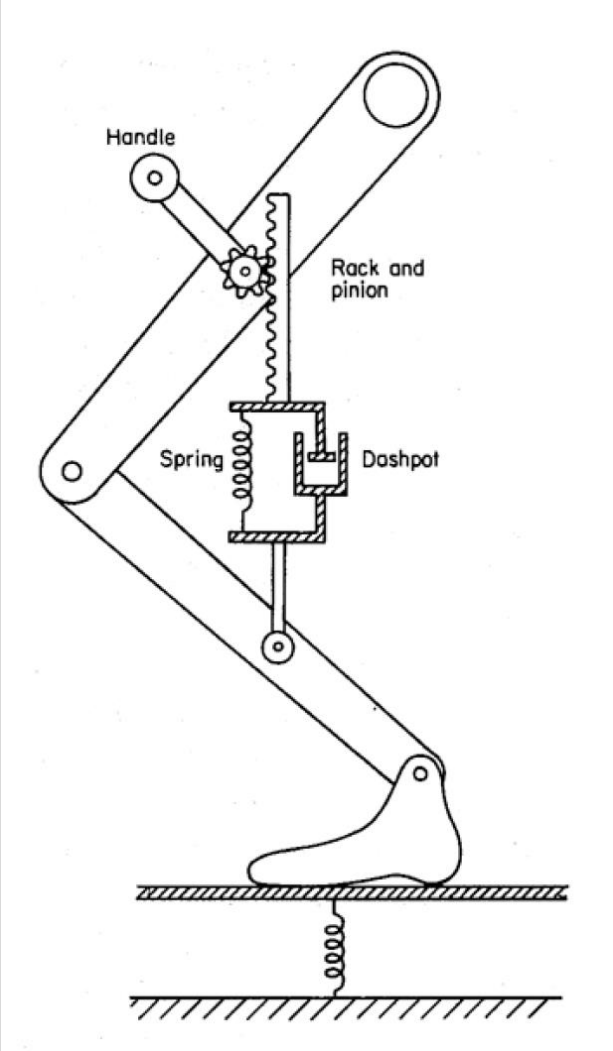
Musculoskeletal Biomechanics



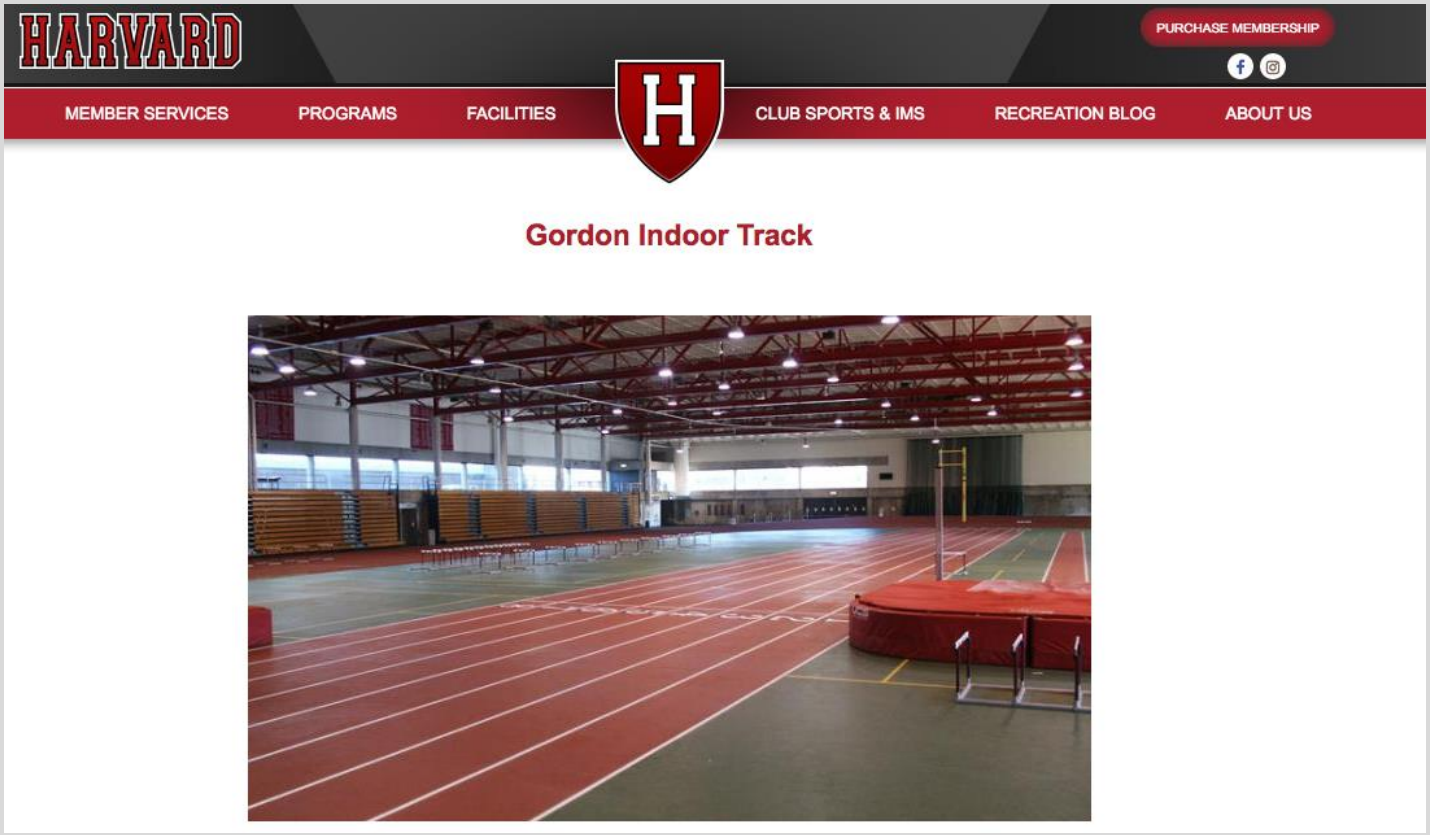
Musculoskeletal Biomechanics



- Enabling
- Enhancing
- Protecting



(McMahon and Greene, *J Biomech*, 1979)



"… a tuned track has 11.3% ± 1.21% force reduction…"

"… decreased injuries by 50%."

"… increase[d] running speeds by 2-3%" (5 sec. / mile)

(McMahon and Greene, *J Biomech*, 1979; Greene and Medved, *Biol Eng Med*, 2019)

THE FIGHT TO BUILD THE WORLD'S FASTEST SHOE

BY JOE LINDSEY

NIKE DIDN'T TELL RODGER KRAM AND WOUTER Hoogkamer much about the prototype shoe at first. "We knew it had a new foam, called Pebax, and they showed us the carbon [fiber] plate," recalls Kram. The exercise physiologist and longtime director of the University of Colorado Boulder's Locomotion Lab, and Hoogkamer, then a post-doctoral researcher there, were writing a journal paper, published in March 2017, detailing how an elite runner might break the mythical two-hour marathon barrier. One factor they detailed was shoe design, and the two had been given what would become the ZoomX Vaporfly 4% to test.

Explaining how shoe design might help break two hours was tricky, says Kram, because while they had already completed testing on the new shoe, they couldn't include their non-peer-reviewed data in a peer-reviewed journal. So they focused on the weight of the foam midsole, which, based on previous studies, they estimated could improve an athlete's running economy by around one percent.

"The world record at that time [2:02:57 by Kenyan Dennis Kimetto in 2014] was in the Adidas Boost shoe," says Hoogkamer, now a professor at the University of Massachusetts Amherst. However, he adds, "we didn't say you can make the foam better; we said, 'Boost is pretty heavy, so maybe you can make it lighter.'"

As for the Vaporfly testing itself, Kram and Hoogkamer approached it with one simple question: Was it faster?

In May of the following year, Nike provided a teaser of an answer with Breaking2, where Eliud Kipchoge of Kenya came within 25 seconds of the two-hour mark on the Formula One Autodromo Nationale track in Monza, Italy. Even unsuccessful, it was a striking improvement over Kimetto's record, and running fans debated what was responsible for the two percent time drop—the dead-flat track, the pacers, the massive car-mounted clock that also functioned as a draft vehicle, or the prototype shoe Kipchoge wore.

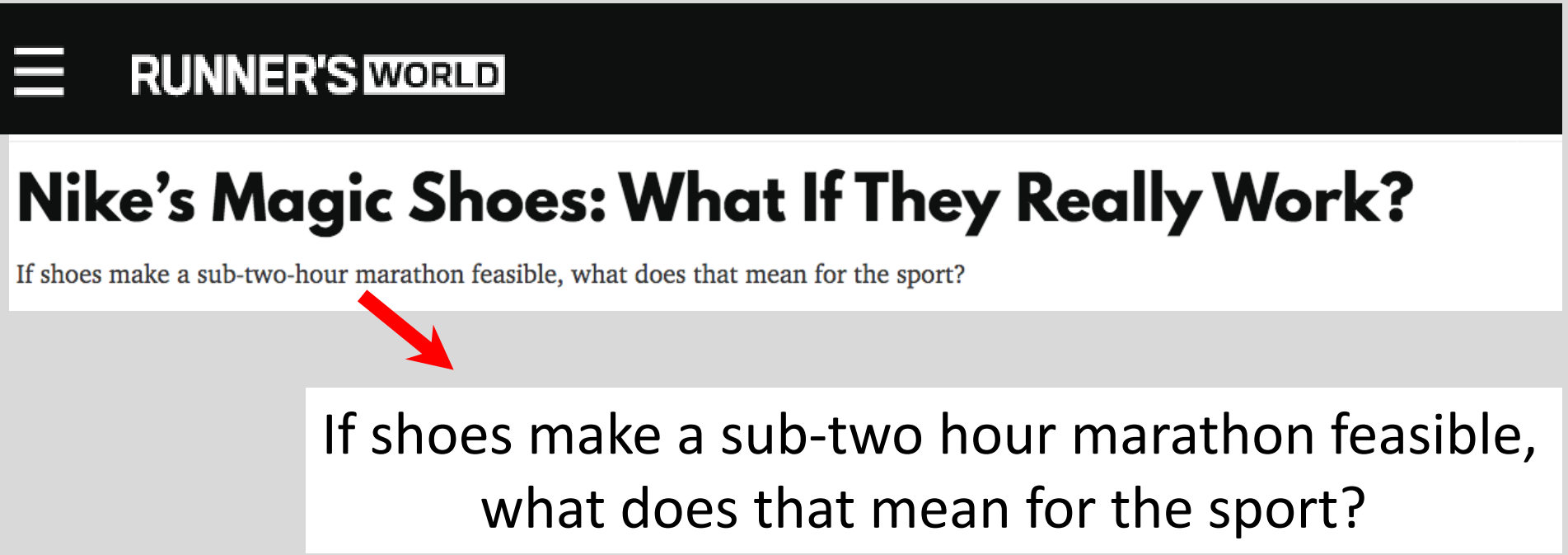
Hoogkamer and Kram's next study, published that fall with the innocuous title "A Comparison of the Energetic Cost of Running in Marathon Racing Shoes," offered a more definitive assessment. The prototype shoe, compared with two top existing models—Nike's Zoom Streak 6 and the Adidas Adizero Adios Boost 2 that Kimetto used in 2014—reduced the metabolic cost of running by four percent. That savings, Hoogkamer and Kram calculated, "should translate to ~3.4 percent improvement in running velocity at marathon world record pace (20.59 km/h)." What's more, because they normalized shoe weight across all

Pacers at the INEOS 1:59 Challenge all wore the Nike ZoomX Vaporfly NEXT%.

RUNNER'S WORLD

Nike's Magic Shoes: What If They Really Work?

If shoes make a sub-two-hour marathon feasible, what does that mean for the sport?



If shoes make a sub-two hour marathon feasible, what does that mean for the sport?

(Paul Gilham, Getty Images)

2012 Paralympic Games – 200m

(www.paralympic.org)

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2012 Olympic Games – 400m

(www.olympicchannel.com)

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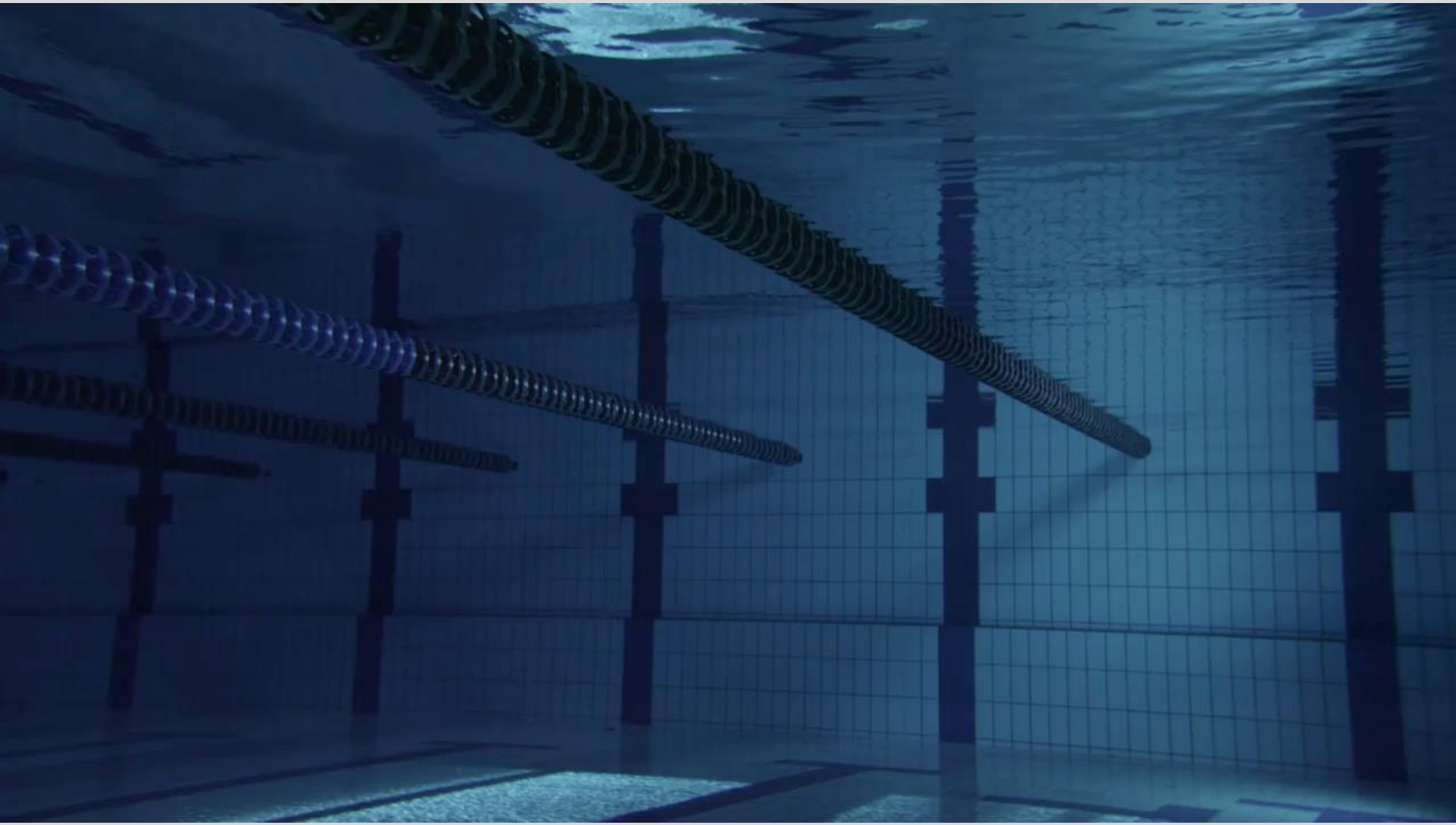

(Speedo International)

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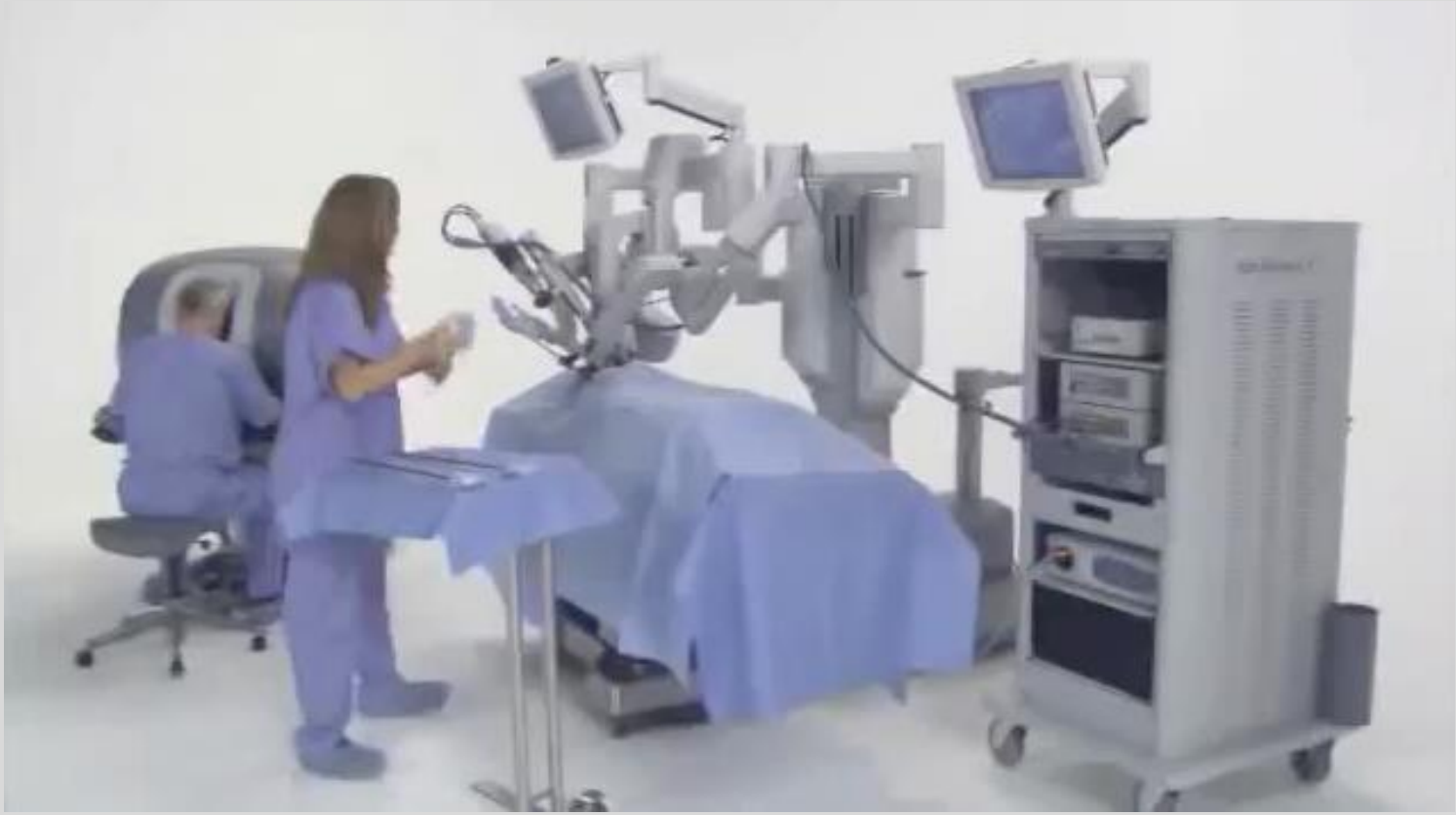
(Loma Linda University Health)



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The following manuscript is on analysis of adverse events in robotic surgical systems during the 14 year period of 2000–2013. This is an update to our analysis which was originally presented at the 50th Annual Meeting of the Society of Thoracic Surgeons in January 2013. Please see Appendix for more detailed results, discussions, and related work.

Adverse Events in Robotic Surgery:

A Retrospective Study of 14 Years of FDA Data

Homa Alemzadeh[1], Ravishankar K. Iyer[1], Zbigniew Kalbarczyk[1], Nancy Leveson[2], Jai Raman[3]

[1]*University of Illinois at Urbana-Champaign - {alemzad1, rkiyer, kalbarcz}@illinois.edu*

[2]*Massachusetts Institute of Technology - leveson@mit.edu*

[3]*Rush University Medical Center - jai_raman@rush.edu*

(Alemzadeh, et al., *PLoS One*, 2016)

Results: During the study period, 144 deaths (1.4% of the 10,624 reports), 1,391 patient injuries (13.1%), and 8,061 device malfunctions (75.9%) were reported. The numbers of injury and death events per procedure have stayed relatively constant since 2007 (mean=83.4, 95% CI, 74.2–92.7). ***Surgical specialties,*** for which robots are extensively used, such as gynecology and urology, had lower number of injuries, deaths, and conversions per procedure than more complex surgeries, such as cardiothoracic and head and neck (106.3 vs. 232.9, Risk Ratio = 2.2, 95% CI, 1.9-2.6). ***Device and instrument malfunctions,*** such as falling of burnt/broken pieces of instruments into the patient (14.7%), electrical arcing of instruments (10.5%), unintended operation of instruments (8.6%), system errors (5%), and video/imaging problems (2.6%), constituted a major part of the reports. ***Device malfunctions impacted patients*** in terms of injuries or procedure interruptions. In 1,104 (10.4%) of the events, the procedure was interrupted to restart the system (3.1%), to convert the procedure to non-robotic techniques (7.3%), or to reschedule it to a later time (2.5%).

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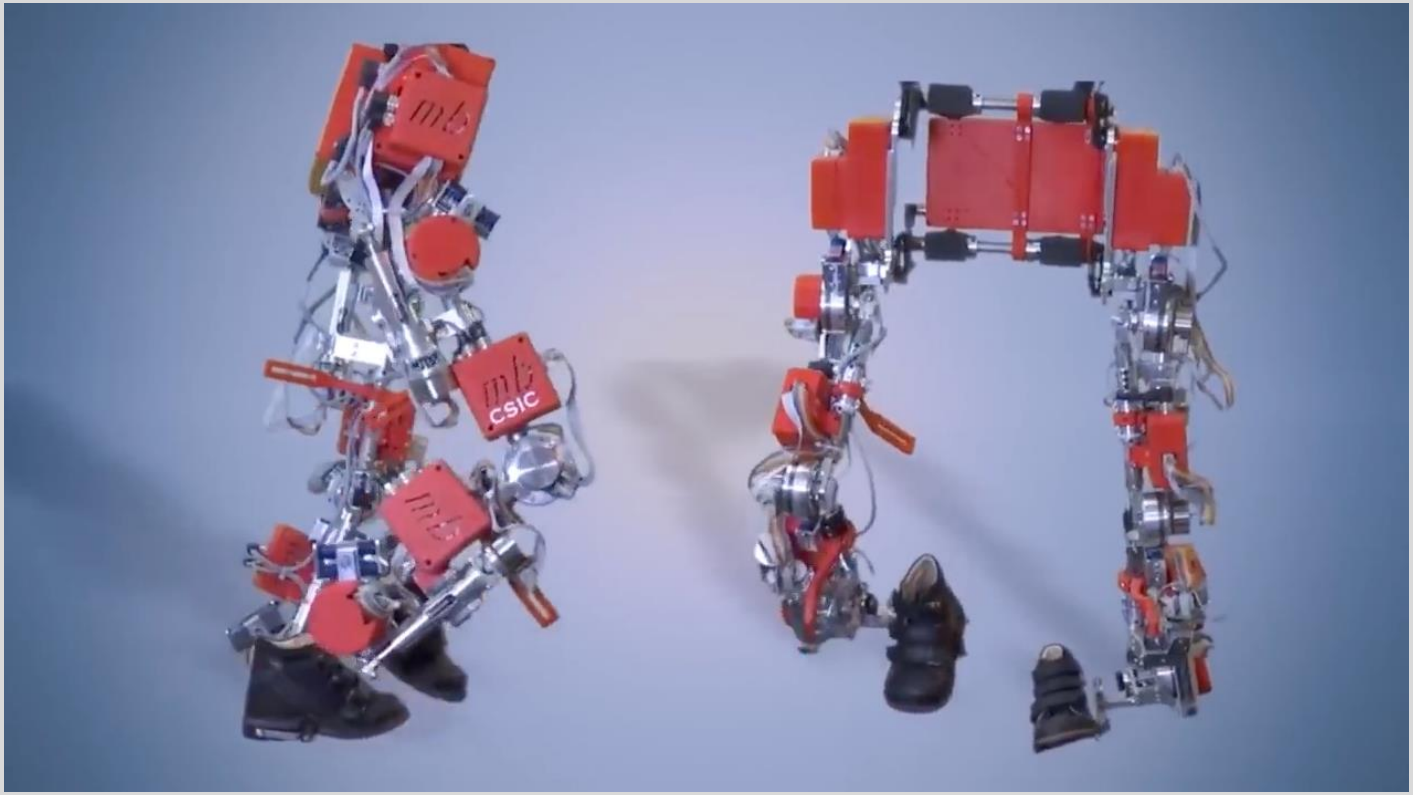
(www.exoskeletonnews.com)



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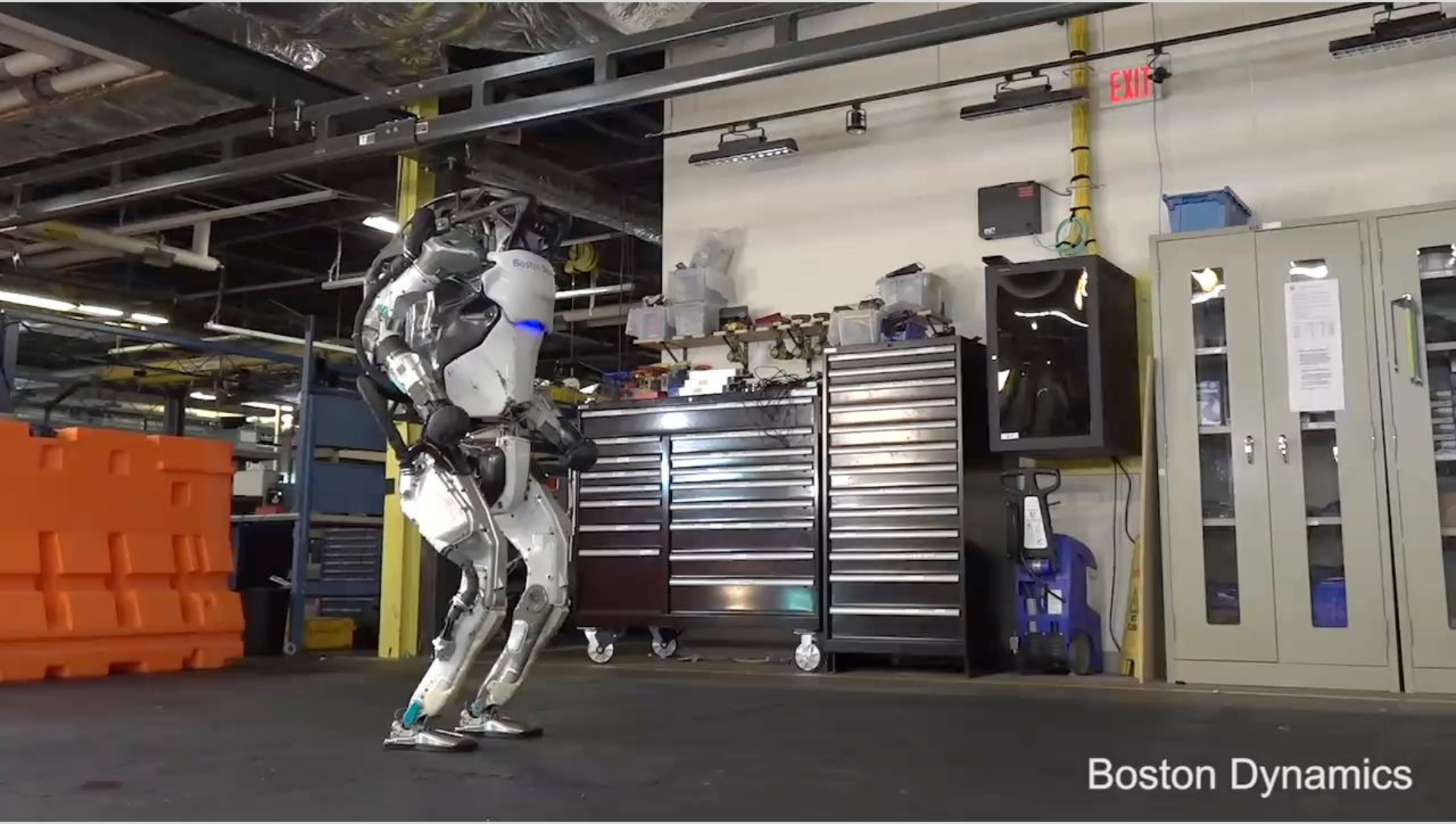

(www.bostondynamics.com)

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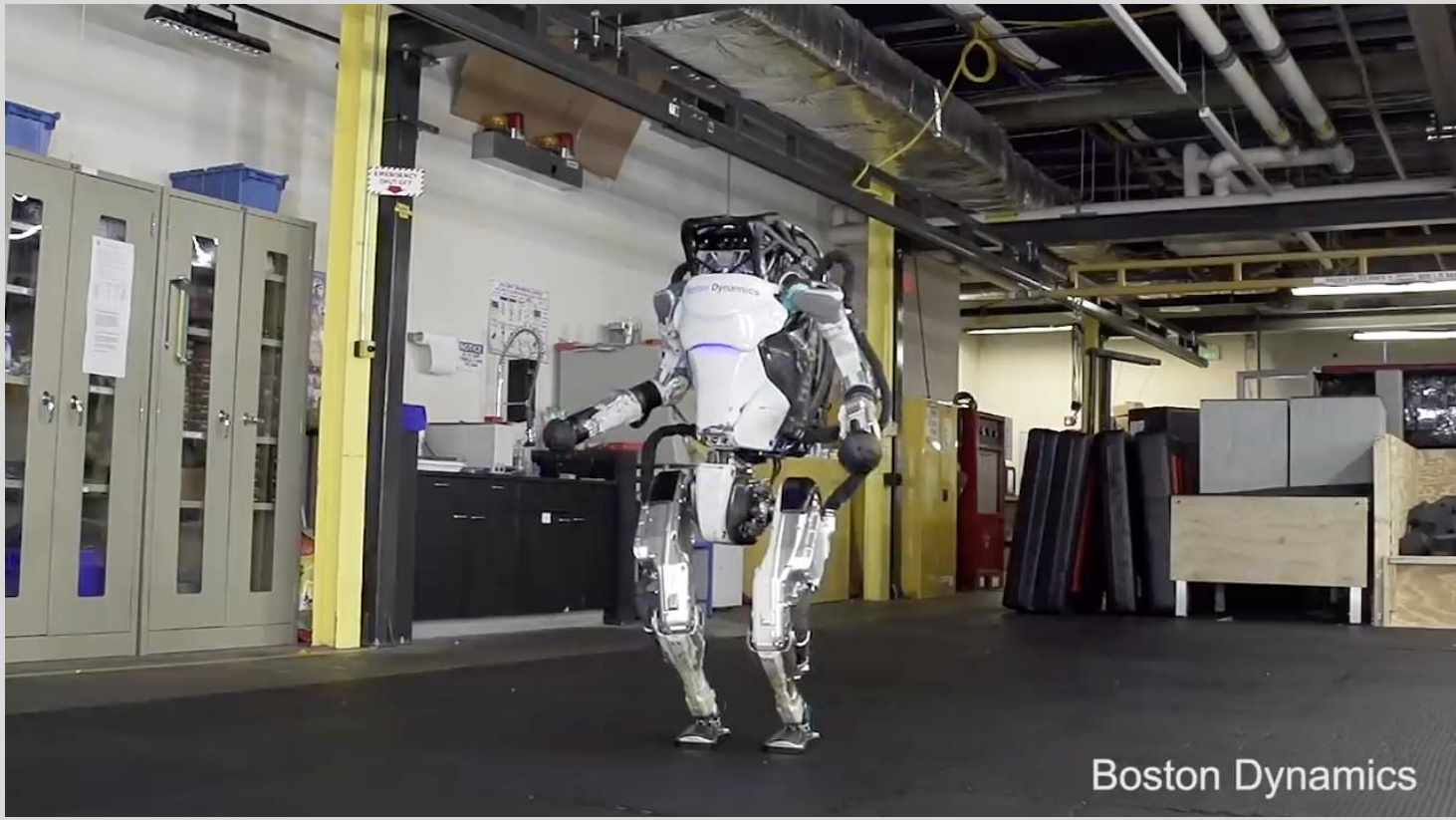

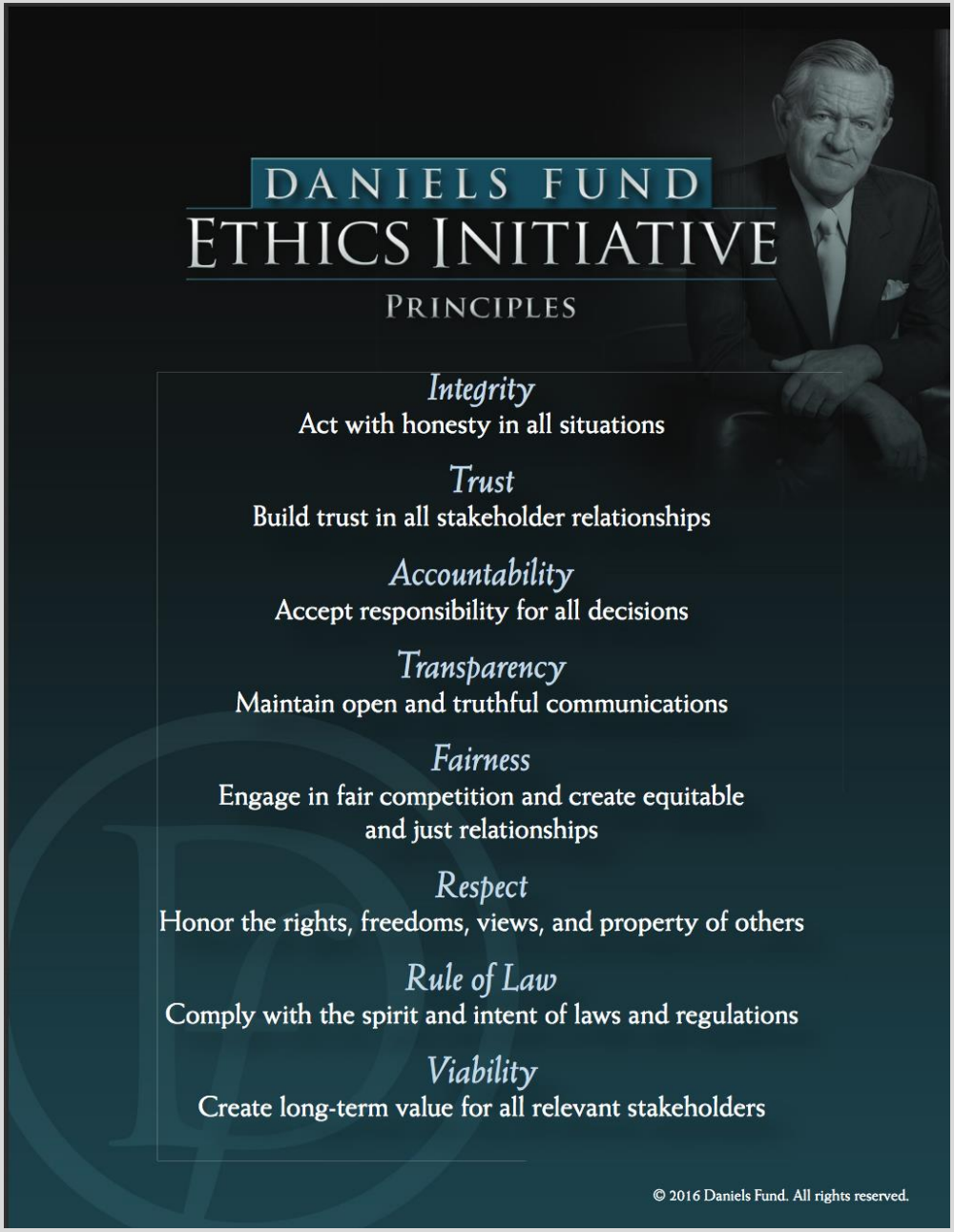

(www.danielsfund.org)