Conceptual Physics NAME:

Homework 1b: Classical Mechanics Homeworks are due usually a day after the corresponding textbook part/lecture is completed. Due dates will be announced in class. Multiple-choice problems will all be marked. **USE** the answer table for these problems. The rest of the homeworks will be marked for apparent completeness and some full-answer problems will/may be marked in detail. Make the full-answer solutions sufficiently detailed that the grader can follow your reasoning. Solutions will be posted eventually after the due dates. The solutions are intended to be (but not necessarily are) super-perfect and often go beyond full answers. For an argument or discussion problem, there really is no single right answer. The instructor's answer reflects his long experience in physics, but there could be objections to his arguments, assumptions, nuances, style, facts, etc.

Answer Table

Name:

	a	b	c	d	e
1.	O	O	O	O	O
2.	O	O	O	O	O
3.	O	O	O	O	O
4.	O	O	O	O	O
5.	O	O	O	O	O
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12.	O	O	O	O	O
13.	O	O	O	O	O
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28.	O	O	O	O	O
29.	O	O	O	O	O
30.	O	O	O	O	O

	a	b	c	d	e
31.	O	O	O	O	O
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42.	O	O	O	O	O
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59.	O	O	O	O	O
60.	O	O	O	O	O

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002 qmult 01300 1 1 3 easy memory: weight defined

1. The force of gravity on an object is, by usual definition, the object's:

   a) acceleration due to gravity. b) mass. c) weight. d) momentum. e) velocity.

   SUGGESTED ANSWER: (c)

   Wrong answers:
   b) Exactly wrong.

   Redaction: Jeffery, 2012jan01

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002 qmult 01310 1 1 3 easy memory: gravitational field

2. The force of gravity on a object is given by

$$\vec{F} = m\vec{g} \ ,$$

   where m is the object mass and g is the ____________ at the object and assumed here to be uniform over the extend of the object.

   a) magnetic field b) electric field c) gravitational field d) gravitational constant
   e) 9.8 N/kg

   SUGGESTED ANSWER: (c)

   Wrong answers:
   d) Big G is the gravitational constant.
   e) This is the fiducial gravitational field magnitude at the Earth's surface.

   Redaction: Jeffery, 2012jan01

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002 qmult 01312 1 1 5 easy memory: g near Earth's surface

3. Near the surface of the Earth, the magnitude of the gravitational field (usually just written g and often called little g) has fiducial (or reference value):

   a) 1.62 N/kg. b) 4.2 N/kg. c) 7.8 N/kg. d) 8.8 N/kg. e) 9.8 N/kg.

   SUGGESTED ANSWER: (e)

   Wrong answers:
   a) This is the Moon's equatorial gravitational field magnitude.

   Redaction: Jeffery, 2012jan01

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002 qmult 01332 1 4 2 easy deducto-memory: free fall

4. "Let's play *Jeopardy*! For $100, the answer is: When a body is acted on only by the force of gravity or in a second meaning acted on only by the forces of gravity and drag."

   What is ____________, Alex?

   a) motion b) free fall c) terminal velocity d) relative velocity
   e) relative acceleration

   SUGGESTED ANSWER: (b)

   Wrong answers:
   a) As Lurch would say AAAARGH.

   Redaction: Jeffery, 2012jan01

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002 qmult 01340 1 3 1 easy math: free-fall speed in 3 seconds

5. How fast is a person falling after 3 s starting from rest? Recall the acceleration due to gravity is $g = 9.8\,\mathrm{m/s^2}$ (which is the fiducial value). Neglect air drag.

   a) 29.4 m/s. b) 44.1 m/s. c) 9.8 m/s. d) 88.2 m/s. e) At the speed of light.

   SUGGESTED ANSWER: (a)

Behold:

$$y = gt = 9.8 \times 3 = 29.4\,\mathrm{m/s}\ .$$

Wrong answers:
e) Wow.

Redaction: Jeffery, 2008jan01

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002 qmult 01342 1 3 1 easy math: kinematic equations: free fall distance
Extra keywords: in 3 seconds

6.* A human falls off some high scaffolding. About how far does he/she fall in 3 seconds? (Neglect air drag.)

a) 44 m. b) 88 m. c) 22 m. d) 9.8 m. e) 4.9 m.

SUGGESTED ANSWER: (a)

Use the kinematic equation

$$y = \frac{1}{2}at^2 + v_0 t + y_0$$

to find

$$y = \frac{1}{2}gt^2 = \frac{1}{2} \times 9.8 \times 9 = 4.9 \times 9 = 44.1\,\mathrm{m}\ .$$

Wrong answers:

Redaction: Jeffery, 2001jan01

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002 qmult 01350 1 4 3 easy deducto-memory: terminal velocity defined
Extra keywords: physci

7. "Let's play *Jeopardy*! For $100, the answer is: It occurs to a dense falling object falling near the Earth's surface when the force of gravity and the force of air drag (AKA air resistance) cancel to give no net force on an object."

What is ____________, Alex?

a) acceleration upward b) acceleration downward c) terminal velocity
d) initial velocity e) parabolic motion

SUGGESTED ANSWER: (c)

Actually buoyancy for must be considered too. So one should say when gravity, drag, and buoyancy force cancel. But for dense objects, the buoyancy force is usually negligible.

Wrong answers:
a) Bad guess.

Redaction: Jeffery, 2001jan01

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002 qmult 01360 3 1 2 easy math: travel time, human terminal velocity 1
Extra keywords: physci

8. The terminal velocity of a human in air is about 120 mi/h. At this speed how long does it take to fall 2 miles.

a) 2 minutes. b) 1 minute. c) 1 hour. d) 2 hours. e) 1 second.

SUGGESTED ANSWER: (b)

The students have to be clear on how you get a time from a distance and speed: distance/speed. In this case

$$\frac{2\,\mathrm{mi}}{120\,\mathrm{mi/h}} = \frac{1}{60}\,\mathrm{h} \times \left(\frac{60\,\mathrm{minutes}}{1\,\mathrm{h}}\right) = 1\,\mathrm{minutes}\ .$$

Wrong answers:
e) As Lurch would say: "Aaaarh."

Redaction: Jeffery, 2001jan01

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002 qmult 01364 1 4 5 easy deducto-memory: cat fall
Extra keywords: mathematical physics

9. "Let's play *Jeopardy*! For $100, the answer is: These features allow cat victims of the high-rise syndrome (i.e., the propensity to taking flying leaps into oblivion—cats being so darn smart you know) to survive falls of more than $\sim 20\,\text{m}$ without major injuries—sometimes that is."

What are ____________, Alex?

a) feline insouciance, savoir-faire, panache, et je-ne-sais-quoi.
b) the cat **WRONGING** reflex and relatively **LOW** terminal velocity when spread-eagled
c) the cat **WRONGING** reflex and relatively **HIGH** terminal velocity when spread-eagled
d) the cat **RIGHTING** reflex and relatively **HIGH** terminal velocity when spread-eagled
e) the cat **RIGHTING** reflex and relatively **LOW** terminal velocity when spread-eagled

SUGGESTED ANSWER: (e)

See

http://en.wikipedia.org/wiki/Cat_righting_reflex

and

http://en.wikipedia.org/wiki/High-rise_syndrome .

Wrong answers:
a) Or so cats would have you believe.

Redaction: Jeffery, 2008jan01

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002 qmult 01380 1 4 2 easy deducto-memory: projectile motion

10. "Let's play *Jeopardy*! For $100, the answer is: Without qualifications, one usually means the non-powered flight of an object in the air or through space. The simplest in-air case is the one in which air drag is neglected. The science of such motions is ballistics.

What is ____________, Alex?

a) apparent motion b) projectile motion c) one-dimensional motion
d) trigonometric motion e) unstoppable motion

SUGGESTED ANSWER: (b)

Wrong answers:
d) A nonsense answer.

Redaction: Jeffery, 2008jan01

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002 qmult 01382 2 1 1 mod. deducto-mem.: gravity is always downward on Earth
Extra keywords: physci

11. A ball is tossed into the air and falls to the ground some distance away. Consider its motion in the vertical direction only and neglect air drag.

a) The ball has a constant acceleration downward.
b) The ball first accelerates **UPWARD** on its rising path and then accelerates **DOWNWARD** on its falling path.
c) The ball first accelerates **DOWNWARD** on its rising path and then accelerates **UPWARD** on its falling path.
d) The ball does not accelerate at all.
e) The ball is always accelerating in the upward direction.

SUGGESTED ANSWER: (a)

An easy memory question. Acceleration due to gravity alone is always downward and is a nearly constant near the Earth's surface. The magnitude of acceleration due to gravity alone is the magnitude of the gravitational field. Near the Earth's surface the gravitational field magnitude has fiducial value $g = 9.8\,\text{m/s}^2$.

Wrong answers:

Redaction: Jeffery, 2001jan01

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002 qmult 01384 1 5 2 moderate thinking: projectile parabolic arc

12. Which best describes the path of a ball thrown on level ground at an angle 30° above the horizontal as seen from a side view.

   a) Two straight lines that meet at an apex: one for the rising phase; one the declining phase. The rising phase line is **TWICE** the length of the declining phase line.
   b) A smooth curve that rises and falls with distance. As far as the eye can tell, the curve could be parabolic.
   c) Two straight lines that meet at an apex: one for the rising phase; one the declining phase. The rising phase line is **HALF** the length of the declining phase line.
   d) A smooth curve that rises and falls with distance, but suddenly breaks off and descends vertically.
   e) A smooth curve that rises and falls with distance and then rises and falls again with distance. A Bactrian camel curve.

SUGGESTED ANSWER: (b)

An easy thinking question. People should be able to identify the only answer that corresponds to common observation. And some may have heard that projectile motion is parabolic aside from air drag effects. Neglecting air drag, the path is, in fact, a parabolic arc as function of the horizontal coordinate x. To understand this note that the vertical height is parabolic with time. The x distance is linear in time. Therefore the vertical height is parabolic with time.

Wrong answers:

   e) A two-hump camel curve?

Redaction: Jeffery, 2001jan01

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002 qmult 01400 1 1 5 easy memory: definition of vector momentum

13. Momentum (or linear momentum) is given by the formula:

   a) $\vec{p} = \dfrac{m}{\vec{v}}$.   b) $\vec{p} = \dfrac{\vec{v}}{m}$.   c) $\vec{p} = \dfrac{1}{2}mv^2$.   d) $\vec{p} = \dfrac{1}{2}m\vec{v}$.   e) $\vec{p} = m\vec{v}$.

SUGGESTED ANSWER: (e)

Wrong answers:

   a) Division by a vector is not defined.
   c) The right-hand side is kinetic energy.

Redaction: Jeffery, 2001jan01

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002 qmult 01430 2 5 1 moderate thinking: KE change and momentum change

Extra keywords: physci KB-94-13

14. If the kinetic energy of an object is doubled, the momentum magnitude changes by a factor of:

   a) $\sqrt{2}$.   b) 2.   c) 1/2.   d) $1/\sqrt{2}$.   e) 1.

SUGGESTED ANSWER: (a)

Recall $\vec{p} = m\vec{v}$, and thus $\vec{v} = \vec{p}/m$. Thus, $KE = mv^2/2 = p^2/(2m)$, and thus $p = \sqrt{2mKE}$. Thus, momentum magnitude increases as the square root of KE. Thus, if KE increases by 2, momentum magnitude increases by $\sqrt{2}$.

Wrong answers:

   b) Not a good guess, but better than some others anyway.

Redaction: Jeffery, 2001jan01

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002 qmult 01440 1 1 2 easy memory: conservation of momentum

Extra keywords: physci

15. For a system on which no net external force acts, momentum is:

a) not conserved. b) conserved. c) zero. d) never zero. e) always negative.

SUGGESTED ANSWER: (b)

Wrong answers:
c) Sometimes, but not always.
e) A negative momentum really only makes sense in 1-dimensional problems where one dispenses with vector notation and makes one sense positive and one sense negative.

Redaction: Jeffery, 2001jan01

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002 qmult 01480 1 1 1 easy memory: operation of rocket
Extra keywords: physci KB-92-9

16. The operation of a rocket in space is based on:

a) conservation of momentum. b) conservation of angular momentum. c) jet fuel pushing on the vacuum. d) starlight pressure. e) running an internal treadmill.

SUGGESTED ANSWER: (a)

Wrong answers:
d) It has been suggested by some, like Arthur C. Clarke, that light pressure could be used for sailing in space. But this is probably only possible within solar systems.
e) This is the hamster theory of space travel.

Redaction: Jeffery, 2001jan01

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002 qmult 01500 1 4 5 easy deducto-memory: energy definition

17. "Let's play *Jeopardy*! For $100, the answer is: It is the conserved essence of structure and transformability."

What is ____________, Alex?

a) the gravitational field b) momentum c) matter d) momentum
e) a suggested definition of energy

SUGGESTED ANSWER: (e)

Wrong answers:
a) As Lurch would say AAAARGH.

Redaction: Jeffery, 2012jan01

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002 qmult 01510 1 1 3 easy memory: energy generality utility

18. Virtually all physical processes (and mamy biological and societal processes too) can be partially (and usually only partially) described as transformations of ____________. This is what gives the concept of ____________ its great generality and power.

a) velocity b) momentum c) energy d) acceleration e) nuclear fusion

SUGGESTED ANSWER: (c)

Wrong answers:
a) As Lurch would say AAAAaarrgh.

Redaction: Jeffery, 2012jan01

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002 qmult 01410 1 1 1 easy memory: history of energy

19. Aristotle (384–322 BCE) introduced energy (in Greek energeia) as a vague philosophical concept that even he admitted was hard to define. It lingered in philosophical discourse until Thomas Young (1773–1829) gave a definite meaning as what we now call kinetic energy. In the course, of the 19th century other forms of energy were discovered all connected by the fact that that each one was tranformable into any of the others and the amount of energy overall was conserved. The process of finding new energy forms can be reached a high point when Albert Einstein (1879–1955) in 1905 discovered the equation:

a) $E = mc^2$. b) $E = mc^3$. c) $KE = (1/2)mv^2$. d) $PE = mgy$. e) $E = KE + PE$.

SUGGESTED ANSWER: (a)

Wrong answers:
b) As Lurch would say AAAaarrgh.

Redaction: Jeffery, 2012jan01

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002 qmult 01520 1 1 3 easy memory: conservation of energy 1

20. The principle of conservation of energy is that energy is never:

a) adequately defined. b) destroyed, but can be created. c) created or destroyed. d) created, but can be destroyed. e) destroyed.

SUGGESTED ANSWER: (c)

Wrong answers:
a) It never is adequately defined, but that's not the principle.

Redaction: Jeffery, 2008jan01

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002 qmult 01530 1 1 1 easy memory: dimensions of energy

21. The physical dimensions of energy are:

a) $\mathrm{ML^2/T^2}$. b) $\mathrm{ML/T^2}$. c) $\mathrm{ML^2}$. d) $\mathrm{ML^2/T}$. e) $\mathrm{M/T^2}$.

SUGGESTED ANSWER: (a)

Wrong answers:
b) The dimensions of force.

Redaction: Jeffery, 2008jan01

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002 qmult 01532 1 1 1 easy memory: unit of energy, the joule
Extra keywords: physci

22. The standard SI unit of energy and of work is the:

a) joule (J). b) newton (N). c) kelvin (K). d) bassingthorp (B). e) trufflehunter (T).

SUGGESTED ANSWER: (a)

Here's a versicle from the poem016.tex file:

The unit of energy is the joule
and this rhymes with drool,
but it should rhyme with bowel
to be correct for James Joule.

Wrong answers:
e) Trufflehunter was a character in the Narnia stories by C.S. Lewis.

Redaction: Jeffery, 2001jan01

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002 qmult 01540 2 1 1 moderate memory: energy necessity and sufficiency
Extra keywords: physci

23. That one has enough energy for a certain job or transformation that requires energy E is a ________________ condition, but **NOT** a ________________ condition for the job or transformation.

a) necessary; sufficient b) sufficient; necessary c) inevitable; necessarily so d) harmonious; ceremonious e) forbidden; given

SUGGESTED ANSWER: (a) Given the wrong answers, I think this answer must inevitably and necessarily be the best.

Wrong answers:
b) The question says the job needs a certain amount of energy; thus having enough is necessary.
c) You don't have enough energy inevitably: the "not necessarily so" part is right.

e) "Not necessarily so."

Redaction: Jeffery, 2001jan01

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002 qmult 01550 1 4 5 easy deducto-memory: energy and money
Extra keywords: physci

24. "Let's play *Jeopardy*! For \$100, the answer is: Because of its protean nature, energy is very much like this thing in everyday human life which, however, unlike energy is not conserved."

What is/are ____________, Alex?

a) furs b) assignats c) shells d) gold e) money

SUGGESTED ANSWER: (e)

This a rather subjective question, but it's hard to imagine anyone who understands the concepts could not choose answer (e).

Wrong answers:
a) You know in the fur trading days in Canada beaver pelts were sort of like money.
b) During the French Revolution assignats were effectively currency backed up by the value of nationalized church lands.

Redaction: Jeffery, 2001jan01

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002 qmult 01600 1 4 2 easy deducto-memory: work defined

25. "Let's play *Jeopardy*! For \$100, the answer is: In physics, it is a macroscopic process of energy transfer."

What is ____________, Alex?

a) energy b) work c) force d) weight e) sloth

SUGGESTED ANSWER: (b)

Wrong answers:
e) Now is this likely?

Redaction: Jeffery, 2008jan01

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002 qmult 01602 1 1 2 easy memory: differential work formula

26. The differential work formula is:

a) $dW = \vec{F}\,d\vec{s}$. b) $dW = \vec{F}\cdot d\vec{s}$. c) $dW = \vec{F}/d\vec{s}$. d) $dW = F\,ds$. e) $dW = \vec{F}\times d\vec{s}$.

SUGGESTED ANSWER: (b)

Wrong answers:
d) A valid one-dimensional form.

Redaction: Jeffery, 2008jan01

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002 qmult 01604 1 1 3 easy memory: work formula for a constant force 2
Extra keywords: For the vector and dot product literate

27. A constant force $\vec{F}$ acts on a body while that body moves a distance $\Delta\vec{r}$. The work W done on the body by the force is given by:

a) $W = \vec{F}/\Delta\vec{r}$. b) $W = \vec{F}$. c) $W = \vec{F}\cdot\Delta\vec{r}$. d) $W = \vec{F}\cdot\vec{F}\cdot\Delta\vec{r}$. e) $W = \vec{F}\cdot\Delta\vec{r}\cdot\Delta\vec{r}$.

SUGGESTED ANSWER: (c)

a) Vectors cannot be simply divided.
b) Vectors can't equal scalars.
d) A triple vector dot product is not a defined operation.
e) A triple vector dot product is not a defined operation.

Wrong answers:

Redaction: Jeffery, 2001jan01

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002 qmult 01610 1 3 1 easy math: work lifting 100 kg load
Extra keywords: physci KB-95-3

28. How much work is done by a lifter lifting a 100 kg load straight upward 10 m without acceleration?

a) 9800 J. b) 100 J. c) 1000 J. d) 10 J. e) 980 J.

SUGGESTED ANSWER: (a)

The calculation is

$$W = Fd\cos\theta = mgd\cos\theta = 100 \times 9.8 \times 10 \times 1 = 9800\,\mathrm{J}\ ,$$

where F is force (which must be equal in magnitude to gravity), d is distance, m is mass, $\cos\theta = 1$ is the cosine of the angle between the lifting force, and the displacement and $g = 9.8\,\mathrm{m/s^2}$ is the acceleration due to gravity constant.

Wrong answers:
d) Not a good guess.

Redaction: Jeffery, 2001jan01

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002 qmult 01612 1 3 1 easy math: work lifting ostrich
Extra keywords: physci KB-93-21

29. The work done by the lifting force of a person lifting a 30 kg ostrich to a height of 30 m without acceleration is about:

a) 9000 J. b) 900 J. c) 300 J. d) 3 J. e) 4500 J.

SUGGESTED ANSWER: (a)

For there to be no acceleration, the lifting force must cancel gravity. Therefore

$$\vec{F}_{\mathrm{lift}} = mg\hat{y}\ .$$

The work done by the lifting force is

$$W = \int_{\Delta y} \vec{F}_{\mathrm{lift}} \cdot d\vec{s} = mg\int_{\Delta y} dy = mg\Delta y \approx 30 \times 10 \times 30 \times 1 = 9000\,\mathrm{J}\ ,$$

where Δy is the y displacement of the ostrich center of mass.

One actually barely needs a calculation. The work done by the lifter must create the gravitational potential energy which is $mg\Delta y$.

I think that in practice, lifting an ostrich might take more work than this. But on the other hand, it's a rather small ostrich. They usually weigh between about 60 kg and about 130 kg. Still it's likely to be kicking.

Wrong answers:
b) Maybe you forgot to multiply by g.

Redaction: Jeffery, 2001jan01

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002 qmult 01614 1 5 5 easy thinking: no macroscopic work done
Extra keywords: physci KB-95-1

30. A person holds 10 kg grouse at 2.0 m above the ground for 30 s. How much macroscopic net work is done by the person on the grouse?

a) 600 J. b) 20 J. c) 300 J. d) 60 J. e) 0 J.

SUGGESTED ANSWER: (e)

At the macroscopic level there is no change in the system, and so no work is done. Microscopically, in the person's body extra chemical energy must expended to maintain the holding stance, but that is not at the macroscopic level. And there is no easy way to calculate that work anyway and its not done on the grouse who might just as well be resting on a pillar. Actually, 10 kg is really heavy for a grouse I'd guess. Wikipedia hints grouse of a few kilograms are big. But it's just a hypothetical question.

Wrong answers:

a) Nope.

Redaction: Jeffery, 2001jan01

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002 qmult 01630 1 1 3 easy memory: kinetic energy definition

Extra keywords: physci

31. Kinetic energy is:

a) the energy of **POSITION** with formula $KE = mgy$. b) the energy of **MOTION** with formula $KE = mgy$. c) the energy of **MOTION** with formula $KE = (1/2)mv^2$. d) the energy of **POSITION** with formula $KE = (1/2)mv^2$. e) heat energy.

SUGGESTED ANSWER: (c) There are plenty of clues.

Wrong answers:

a) The mgy is the potential energy of gravity near the Earth's surface.

e) Heat energy can be microscopic kinetic energy, but there are other forms of heat energy. When we just say kinetic energy, we are usually thinking of macroscopic kinetic energy.

Redaction: Jeffery, 2001jan01

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002 qmult 01640 1 1 3 easy memory: work-kinetic-energy theorem

32. The work-kinetic-energy theorem is:

a) $KE = \frac{1}{2}mv^2$. b) $\Delta E = W_{\rm non}$. c) $\Delta KE = W$. d) $\Delta KE = \frac{1}{2}W$. e) $\Delta KE = \frac{1}{2}mv^2$.

SUGGESTED ANSWER: (c)

Wrong answers:

a) This is the kinetic energy formula.

b) This is the work-energy theorem.

Redaction: Jeffery, 2008jan01

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002 qmult 01650 2 5 4 moderate math: friction killing KE

Extra keywords: physci KB-95-9

33. A moving object has initial $KE = 100\,\text{J}$ and is subjected to a friction force of magnitude $2\,\text{N}$ and no other forces. How far does the object go before coming to a stop?

a) 100 m. b) 2 m. c) 1000 m. d) 50 m. e) 0 m.

SUGGESTED ANSWER: (d)

Remember the work-kinetic-energy theorem:

$$\Delta KE = W_{\rm net} \ .$$

The work done by a particular constant force is

$$W = \vec{F} \cdot \Delta\vec{r} = F\Delta r \cos\theta ,$$

where $\vec{F}$ is the force, $\Delta\vec{r}$ is the displacement, and $\cos\theta$ is the cosine of the angle between the force and the displacement vectors. In this case the only force is friction and it is a constant. Friction always opposes the direction of motion, and so $\cos\theta = -1$ (from $\theta = 180^\circ$). So in the present case,

$$\Delta r = -\frac{\Delta KE}{F} = -\left(\frac{0-100}{2}\right) = 50\,\text{m} \ .$$

Wrong answers:

e) Not a good guess.

Redaction: Jeffery, 2001jan01

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002 qmult 01700 1 1 2 easy memory: potential energy definition
Extra keywords: physci

34. Potential energy is:

a) the energy of position: it exists for nonconservative forces.
b) the energy of position: it exists for conservative forces.
c) the energy of motion: its formula is $PE = (1/2)mv^2$.
d) the energy of position: its formula is $PE = (1/2)mv^2$.
e) heat energy.

SUGGESTED ANSWER: (b) There are plenty of clues.

Wrong answers:
e) Nah.

Redaction: Jeffery, 2001jan01

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002 qmult 01702 2 1 3 moderate memory: paths and a conservative force

35. The work done by a conservative force on an object while the object moves on a path between two endpoints is:

a) **INDEPENDENT** of the path and endpoints.
b) **DEPENDENT** on the path.
c) **INDEPENDENT** of the path between the endpoints.
d) **DEPENDENT** on the path, but **NOT** on the endpoints.
e) equal to the path length.

SUGGESTED ANSWER: (c)

Wrong answers:
a) This seems to say that in general potential energy is independent of position altogether. Which is wrong.
d) Exactly wrong.
e) Not a dimensionally correct answer to say the least.

Redaction: Jeffery, 2001jan01

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002 qmult 01704 1 4 1 easy deducto-memory: general potential energy formula

36. "Let's play *Jeopardy*! For \$100, the answer is: $\Delta PE = -W$."

a) What is the formula relating **POTENTIAL** energy change in a conservative force field to work done by the conservative force (i.e., what is the general potential energy formula), Alex?
b) What is Faraday's law, Alex?
c) What are capacitors, Alex?
d) What is . . . no, no wait . . . what is unicorn circular motion, Alex?
e) What is the formula relating **KINETIC** energy change in a conservative force field to work done by the conservative force (i.e., what is the work-kinetic-energy theorem), Alex?

SUGGESTED ANSWER: (a)

Wrong answers:
d) A rhinoceros chasing its tail?
e) U is pretty much common for potential energy and never used for kinetic energy to my knowledge.

Redaction: Jeffery, 2001jan01

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002 qmult 01710 1 4 2 easy deducto-memory: energy and heat
Extra keywords: physci KB-73

37. British American Benjamin Thompson (1753–1814), while employed as director of the Bavarian arsenal, noticed that in boring cannon (but not causing cannon ennui) that the boring motion and friction seemed to produce unlimited amounts of heat. He concluded:

a) heat was a substance of which there could only be so much of in any object.
b) that heat was somehow generated by motion and friction. This conclusion eventually led to the recognition of heat as another form of energy that could be converted from or converted into, e.g., mechanical or chemical energy.
c) that heat had no relation to motion and friction and was somehow spontaneously generated by cannon.
d) that cannon could be the plural of cannon.
e) that the biergartens in Munich were much better than the taverns in Boston and that Sam Adams, patriot-founding-father notwithstanding, could have learnt a thing or two about brewing beer.

SUGGESTED ANSWER: (b) Putting a thing or two together the answer should be obvious. This question exemplifies my belief that some questions should be easy, but should drive in an idea like a spike. Anyway I used to stroll by Thompson's statue in the Englischer Gartens sometimes in my Munich days. Hm—should they be called the Amerikaner Gartens if they were named after Thompson (also known as Graf Rumford) as I vaguely seem to recall. There's a very pleasant biergarten, Der Chinisischer Turm in the Englischer Gartens.

Wrong answers:
a) In the 18th century, one theory of heat held that it was a substance that was conserved independently of anything else: a subtle fluid perhaps.
d) Probably English speakers (or as we call them in Canada Anglophones or Anglos or darned Anglos) already knew this in the 18th century and it's not even relevant either.
e) Personal experience suggests this was true in the late 20th century, but for the 18th century I'm just guessing. It certainly isn't the best answer in the context of the question.

Redaction: Jeffery, 2001jan01

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002 qmult 01720 1 4 1 easy deducto-memory: work-energy theorem
38. "Let's play *Jeopardy*! For \$100, the answer is: $\Delta E = W_{\text{nonconservative}}$."

What is the ____________, Alex?

a) work-energy theorem b) work-kinetic-energy theorem c) potential-energy-work formula
d) work-potential-energy theorem e) kinetic energy formula

SUGGESTED ANSWER: (a)

Wrong answers:
e) As Lurch would say AAAARGH.

Redaction: Jeffery, 2008jan01

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002 qmult 01722 1 1 4 easy memory: mechanical energy conservation
Extra keywords: physci
39. Mechanical energy is the sum of kinetic energy and potential energy. It is a conserved quantity:

a) always.
b) whenever it has both kinetic and potential energy components.
c) if all the forces that do net work are **NONCONSERVATIVE**.
d) if all the forces that do net work are **CONSERVATIVE**.
e) whenever it is positive.

SUGGESTED ANSWER: (d)

Wrong answers:
a) Nah.

Redaction: Jeffery, 2001jan01

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002 qmult 01730 1 3 5 easy math: dog drops brick mech. energy conserved

Extra keywords: physci

40. A brick has mass 1 kg. A dog (from a joke that I'll tell you someday) drops the brick (which it was holding in its mouth or, one might say, with its jowl) 1 m. What is the kinetic energy of the brick just before it hits the ground? **HINT:** The calculator is superfluous.

a) 9.8 watts. b) 9.8 gems. c) 9.8 newtons. d) 9.8 jowls. e) 9.8 joules.

SUGGESTED ANSWER: (e)

The potential energy at 1 meter of a 1 kilogram brick is 9.8 joules. If it drops 1 meter its potential energy becomes zero and its kinetic energy becomes 9.8 joules by the conservation of mechanical energy.

Wrong answers:

d) James Prescott Joule (1818–1889) British physicist and brewer proved that mechanical, heat, and chemical energies were all different forms of the same thing within experimental uncertainty. He was one of the last of the great gentleman scientists. He actually pronounced his name jowl (rhymes with bowel), but in the interests of euphony we usually pronounce the unit named after him jool (rhymes with drool).

Redaction: Jeffery, 2001jan01

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002 qmult 01800 1 1 1 easy memory: power definition

Extra keywords: physci

41. Work per unit time or energy transformed per unit time is:

a) power. b) might. c) oomph. d) strength. e) pay.

SUGGESTED ANSWER: (a)

Wrong answers:

e) Not the best answer in this context.

Redaction: Jeffery, 2001jan01

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002 qmult 01820 1 5 3 easy thinking: sunlight power

Extra keywords: physci KB-99-17

42. If you could capture it all for useful work, the energy sunlight delivers to a square meter of ground would run one or two ordinary incandescent light bulbs. The power delivered by the Sun to a square meter of ground on average is to order or magnitude:

a) 1 W. b) 10 W. c) 100 W. d) 10^6 W. e) 1 MW.

SUGGESTED ANSWER: (c)

The solar constant is the solar flux above the atmosphere in the direction perpendicular to the cross sectional area of the Earth: it is about 1370 W/m^2. The Earth captures solar power over an area of πR^2, where R is the radius of the Earth. But this must be spread on average over the Earth's spherical surface which has an area of $4\pi R^2$. This reduces the average capture per square meter by a factor of 4. Only about half of this captured power reaches the ground. Thus at the ground, the Sun delivers about 170 W/m^2 (Smil2006–27).

Rounding 170 W/m^2 to order of magnitude gives 100 W/m^2.

Wrong answers:

a) C'mon, ordinary light bulbs require tens to hundreds of watts.

e) A megawatt is the same as 10^6 W.

Redaction: Jeffery, 2001jan01

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002 qmult 01822 2 5 2 moderate thinking: boy running up stairs

Extra keywords: physci KB-93-23

43. A 50 kg boy runs up a flight of stairs of 5 m in height in 5 s at a constant rate. His power output just to work against gravity is:

a) 50 W. b) 490 W. c) 980 W. d) 10^6 W. e) 1 MW.

SUGGESTED ANSWER: (b)

Note we are just counting his power to do work against gravity. A real boy—unlike Pinocchio—would have use power to work against friction internal and external and to make motions that sustain his balance as well as all the usual life sustaining bodily functions. But the question only concerns his work against gravity. Also he is an ideal boy.

The calculation is

$$P = \frac{W}{\Delta t} = \frac{mg\Delta y}{\Delta t} = \frac{50 \times 9.8 \times 5}{5} = 490\,\mathrm{W} \ ,$$

where P is power, W is work done, $g = 9.8\,\mathrm{m/s^2}$ m is mass, Δy is the change in height, and $mg\Delta y$ is the gravitiatonal potential energy change which must equal the work done against gravity.

Wrong answers:

e) Superboy flies again.

Redaction: Jeffery, 2001jan01

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002 qmult 01824 2 5 2 moderate thinking: mountain climber power output

Extra keywords: physci KB-95-7

44. A 100 kg mountain climber climbs 4000 m in 10 hours. What is his power output going into gravitational potential energy? What is his total power output?

a) 3.92×10^6 W and 3.92×10^6 W.

b) The power going into gravitational potential energy is 109 W. His total power output cannot be exactly calculated since a lot of power must go into waste heat due to frictional forces and into the body heat which is lost to the environment. All one can easily say is that 109 W is a **LOWER BOUND** on the total power output.

c) The power going into gravitational potential energy is 3.92×10^6 W. His total power output cannot be exactly calculated since a lot of power must go into waste heat due to frictional forces and into the body heat which is lost to the environment. All one can easily say is that 3.92×10^6 W is a **LOWER BOUND** on the total power output.

d) The power going into gravitational potential energy is 3.92×10^6 W. His total power output cannot be exactly calculated since a lot of power must go into waste heat due to frictional forces and into the body heat which is lost to the environment. All one can easily say is that 3.92×10^6 W is an **UPPER BOUND** on the total power output.

e) The power going into gravitational potential energy is 109 W. His total power output cannot be exactly calculated since a lot of power must go into waste heat due to frictional forces and and into the body heat which is lost to the environment. All one can easily say is that 109 W is an **UPPER BOUND** on the total power output.

SUGGESTED ANSWER: (b)

Fortran Code

```
        print*
        xmass=100.
        gg=9.8
        hh=4.e+3
        tt=3600.*10.
        energy=xmass*gg*hh
        power=xmass*gg*hh/tt
        print*,'energy,power'
        print*,energy,power
*             3920000.        108.8889
```

Wrong answers:

e) All things are wrong.

Redaction: Jeffery, 2001jan01

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002 qmult 02000 1 4 2 easy deducto-memory: Newton gravitation law

45. "Let's play *Jeopardy*! For $100, the answer is: He/she discovered the gravitation law (AKA universal law of gravitation) of classical physics. This law shows that the same gravity that holds on Earth also holds throughout the space—insofar as classical physics applies."

Who is ____________, Alex?

a) Galileo (1564–1642) b) Isaac Newton (1643–1727) c) James Clark Maxwell (1831–1879) d) Albert Einstein (1879–1955) e) Emmy Noether (1882–1935)

SUGGESTED ANSWER: (b)

Wrong answers:
d) He discovered general relativity which supersedes classical gravity physics.

Redaction: Jeffery, 2008jan01

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002 qmult 02002 1 1 3 easy memory: Newton's Apple

46. William Stukeley (1687–1765) recorded a conversation with Newton at Kensington, 1726 April 15 (less than year before Newton's death at 84):

"when formerly, the notion of gravitation came into his mind. It was occasioned by the fall of a/an __________, as he sat in contemplative mood. Why should that ____________ always descend perpendicularly to the ground, thought he to himself. Why should it not go sideways or upwards, but constantly to the earth's centre."

a) peach b) pear c) apple d) orange e) sparrow

SUGGESTED ANSWER: (c)

Wrong answers:
d) Now how many orange trees are there in England? OK, OK, in greenhouses. But there were very few greenhouses at Woolsthorpe Manor in Woolsthorpe-by-Colsterworth, Lincolnshire in 1666.

Redaction: Jeffery, 2008jan01

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002 qmult 02010 1 1 1 easy memory: gravity attracts always
Extra keywords: physci

47. Gravity is the force between systems with mass and it is:

a) always attractive. b) always **REPULSIVE**, except perhaps in some cosmological applications. c) either attractive or **REPULSIVE**. d) neither attractive nor **REPULSIVE**. e) neither fish nor fowl.

SUGGESTED ANSWER: (a) There are some cosmological cases where something like a repulsive gravity is invoked. But at present no one likes to call that antigravity.

Wrong answers:
e) A nonsense answer.

Redaction: Jeffery, 2001jan01

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002 qmult 02020 1 1 4 easy memory: Newton's law of gravity

48. Newton's law of gravity (or the universal law of gravity) for the force exerted by point mass 1 on point mass 2 (where from 1 to 2 is indicated by subscript 12) is:

a) $\vec{F}_{12} = -Gm_1 m_2 r^2 \hat{r}_{12}$. b) $\vec{F}_{12} = -\dfrac{Gm_1}{m_2} r^2 \hat{r}_{12}$. c) $\vec{F}_{12} = -\dfrac{Gm_1}{m_2} r\hat{r}_{12}$.
d) $\vec{F}_{12} = -\dfrac{Gm_1 m_2}{r^2} \hat{r}_{12}$. e) $\vec{F}_{12} = -\dfrac{Gm_1 m_2}{r^3} \hat{r}_{12}$.

SUGGESTED ANSWER: (d)

Wrong answers:
a) Can the force of gravity get stronger with separation?

Redaction: Jeffery, 2001jan01

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002 qmult 02022 1 1 2 easy memory: 3rd law of motion and gravity

49. Newton's law of gravity is:

    a) inconsistent with Newton's 3rd law of motion.
    b) consistent with Newton's 3rd law of motion. c) violates Newton's 3rd law of motion.
    d) Newton's 3rd law of motion. e) Newton's 2nd law of motion.

    SUGGESTED ANSWER: (b)

    Wrong answers:
    a) Exactly wrong.

    Redaction: Jeffery, 2008jan01

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002 qmult 02024 1 4 5 easy deducto-memory: gravitational constant

50. "Let's play *Jeopardy*! For \$100, the answer is: It is the gravitational constant with MKS units $\mathrm{N\,m^2/kg^2}$ It is actually the poorest known of the fundamental constants because gravity is such a weak force between laboratory size objects which are used to measure it."

    What is ____________, Alex?

    a) $1.000\ldots$ b) $2.99792458 \times 10^{-8}$ c) 2.99792458×10^{8} d) $6.67384(80) \times 10^{11}$
    e) $6.67384(80) \times 10^{-11}$

    SUGGESTED ANSWER: (e) This is the Wikipedia value (2011sep11).

    Wrong answers:
    c) This is the speed of light.

    Redaction: Jeffery, 2008jan01

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002 qmult 02030 1 1 1 easy memory: fiducial gravitational force

51. A fiducial gravitational force is the force between two non-overlapping spherically symmetric objects each of mass 1 kg with the center-to-center distance one meter. The magnitude of this force is:

    a) 1. b) 1/2. c) 6.67428×10^{11}. d) 1.67×10^{-11}. e) 6.67384×10^{-11}.

    SUGGESTED ANSWER: (e)

    Behold

$$F = \frac{Gm_1m_2}{r_{12}} = \frac{6.67384 \times 10^{-11} \times 1 \times 1}{1^2} = 6.67384 \times 10^{-11}\,\mathrm{N}\ .$$

This is a very small force. It is undetectable by human senses.

In fact, the gravitational force between laboratory sized objects can be measured, but not to wonderful accuracy. This is why the gravitational constant is the poorest known of the fundamental constants. It's current recommended value is $G = 6.67428(67) \times 10^{-11}\,\mathrm{N\,m^2/kg^2}$ (Wikipedia: 2008dec09 and NIST constants 2009may05) is uncertain in the 5th digit place—and some people think the given uncertainty in the brackets is too small.

Wrong answers:
a) A nonsense answer.

Redaction: Jeffery, 2008jan01

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002 qmult 02032 1 3 3 easy math: gravity force calculation

52. Using Newton's gravitation law

$$\vec{F}_{12} = -\frac{Gm_1m_2}{r^2}\hat{r}_{12}$$

($G = 6.67384(80) \times 10^{-11}\,N\,m^2/kg^2$: e.g., Wikipedia 2011sep11) calculate the magnitude of the force between two 3 kg objects 3 m apart. The answer is:

    a) $60.1 \times 10^{-11} \approx 12 \times 10^{-11}$ lb. b) $20.0 \times 10^{-11} \approx 4 \times 10^{-11}$ lb.
    c) $6.674 \times 10^{-11}\,\mathrm{N} \approx 1.5 \times 10^{-11}$ lb. d) $2.224 \times 10^{-11}\,\mathrm{N} \approx 0.5 \times 10^{-11}$ lb.
    e) $0.741 \times 10^{-11}\,\mathrm{N} \approx 0.15 \times 10^{-11}$ lb.

SUGGESTED ANSWER: (c)

Wrong answers:
a) You have to watch numerator and denominator both.

Fortran-95 Code

```
        conv=.2248d0
        f=6.674d-11
        fp=f*conv
        print*,'f,fp'
        print*,f,fp
!  6.674E-11 1.5003151999999997E-11
```

Redaction: Jeffery, 2001jan01

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002 qmult 02040 2 1 3 mod. memory: mass and weight above Earth
Extra keywords: physci KB-59-25

53. An object has mass x and weight y on the Earth's surface. What is its mass and weight at 2 Earth radii above the Earth's surface? Note **ABOVE** the Earth's surface, not **FROM** the Earth's center.

a) x and $y/2$. b) $x/2$ and $y/2$. c) x and $y/9$. d) x and $y/4$. e) $x/9$ and $y/9$.

SUGGESTED ANSWER: (c)

Remember mass is an intrinsic property of a body and doesn't vary with location. It does vary with velocity according to special relativity, but that effect is small for everyday speeds. Weight is the force of gravity on an object. At 2 Earth radii above the surface, the object is at 3 Earth radii from the Earth's center. By the inverse-square law, the weight must be decreased by a factor of 9.

Wrong answers:
d) You may be forgetting to reference the distance to the Earth's center and using the distance to the Earth's surface instead.

Redaction: Jeffery, 2001jan01

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002 qmult 02110 1 1 3 easy memory: free fall in orbit

54. In orbit, you are weightless, not because gravity has turned off—it can actually be quite strong—but because you are in:

a) going circles. b) a relaxed state. c) free fall. d) hallucinating. e) outer space.

SUGGESTED ANSWER: (c)

Wrong answers:
a) Oh, c'mon.

Redaction: Jeffery, 2012jan01