Conceptual Physics

Exam 1 2011 September 23, Friday

NAME:

Instructions: There are 40 multiple-choice questions each worth 1 mark for a total of 40 marks altogether. Choose the **BEST** answer, completion, etc., and darken fully the appropriate circle on the table provided on the next page. Read all responses carefully. **NOTE** long detailed preambles and responses won't depend on hidden keywords: keywords in such preambles and responses are bold-faced capitalized.

There is **ONE** full answer question worth 10 marks. Answer it on the paper provided. Extra paper will be provided if needed. Write legibly.

This is a **CLOSED-BOOK** exam. **NO** cheat sheets allowed. Calculators are permitted for calculations and only calculations. Cell phones **MUST** be turned off. Remember your name (and write it down on the exam too).

The test is out of 50 marks altogether and is a 50-minute test. Remember your name (and write it down on the exam too).

NAME:

Answer Table for the Multiple-Choice Questions

	a	b	c	d	e		a	b	c	d	e
1.	O	O	O	O	O	21.	O	O	O	O	O
2.	O	O	O	O	O	22.	O	O	O	O	O
3.	O	O	O	O	O	23.	O	O	O	O	O
4.	O	O	O	O	O	24.	O	O	O	O	O
5.	O	O	O	O	O	25.	O	O	O	O	O
6.	O	O	O	O	O	26.	O	O	O	O	O
7.	O	O	O	O	O	27.	O	O	O	O	O
8.	O	O	O	O	O	28.	O	O	O	O	O
9.	O	O	O	O	O	29.	O	O	O	O	O
10.	O	O	O	O	O	30.	O	O	O	O	O
11.	O	O	O	O	O	31.	O	O	O	O	O
12.	O	O	O	O	O	32.	O	O	O	O	O
13.	O	O	O	O	O	33.	O	O	O	O	O
14.	O	O	O	O	O	34.	O	O	O	O	O
15.	O	O	O	O	O	35.	O	O	O	O	O
16.	O	O	O	O	O	36.	O	O	O	O	O
17.	O	O	O	O	O	37.	O	O	O	O	O
18.	O	O	O	O	O	38.	O	O	O	O	O
19.	O	O	O	O	O	39.	O	O	O	O	O
20.	O	O	O	O	O	40.	O	O	O	O	O

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001 qmult 00110 1 1 4 easy memory: scientific method described

Extra keywords: physci KB-24-1 but much altered

1. The scientific method can be schematically described as a/an:

   a) square of theorizing and experiment/observation. b) integrative process.
   c) reductive process. d) a cycle of theorizing and experiment/observation.
   e) a pointless pursuit.

   SUGGESTED ANSWER: (d)

   Wrong answers:
   b) Say what?
   c) Say what?
   e) As Lurch would say: "Aaaarh."

   Redaction: Jeffery, 2001jan01

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001 qmult 00300 1 4 5 easy deducto-memory: Eratosthenes circumference

2. "Let's play *Jeopardy*! For $100, the answer is: He was the first person to measure the circumference of the Earth."

   Who is ____________, Alex?

   a) Parmenides (early 5th century BCE)
   b) Democritus (ca. 460–ca. 370 BCE) c) Aristotle (384–322 BCE)
   d) Aristarchus of Samos (c. 310–c. 230 BCE)
   e) Eratosthenes (c. 276–c. 195 BCE)

   SUGGESTED ANSWER: (e)

   Wrong answers:
   a) Perhaps, the inventor of the round Earth theory. On the other hand, it could have been Pythagoras or one of his followers.
   b) A flat-Earther. The Earth was a residue at the bottom of the cosmos membrane.

   Redaction: Jeffery, 2012jan01

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002 qmult 00100 1 4 4 easy deducto-memory: mechanics defined

3. "Let's play *Jeopardy*! For $100, the answer is: It is the branch of physics dealing with the motions of bodies."

   What is ____________, Alex?

   a) electromagnetism b) thermodynamics c) engineering
   d) mechanics e) chemical reactions

   SUGGESTED ANSWER: (d)

   Actually, all branches of physics overlap with each other and are not clearly separated. But the core problems of each branch are clearly enough separated to make the categorization into branches useful.

   Wrong answers:

a) As Lurch would say AAAARGH.

Redaction: Jeffery, 2012jan01

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002 qmult 00250 1 1 2 easy memory: 2-d curved space of a sphere

4. The 2-dimensional surface of a sphere is not a flat space (i.e., not a Euclidean 2-dimensional space). One sign of this is that lines parallel at an equator:

   a) never meet. b) meet at the poles. c) meet 3 times.
   d) diverge from each other away from the equator. e) meet at the equator.

   SUGGESTED ANSWER: (b)

   Wrong answers:
   c) They meet twice: one time at each pole
   e) Only if they are coincident.

   Redaction: Jeffery, 2012jan01

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002 qmult 00300 1 4 1 easy deducto-memory: displacement defined

5. "Let's play *Jeopardy*! For $100, the answer is: It is the vector quantity specifying position relative to some origin. It has length which is the straightline distance from the origin to the position and a direction which is the direction from the origin to the position."

   What is ____________, Alex?

   a) displacement b) velocity c) acceleration d) force e) time

   SUGGESTED ANSWER: (a)

   Wrong answers:
   b) As Lurch would say AAAARGH.

   Redaction: Jeffery, 2012jan01

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002 qmult 00332 1 3 2 easy math: displacements in Vegas 2
Extra keywords: physci

6. You are in Las Vegas where the streets are almost all laid out in a rectangular grid. Assume the grid is exactly aligned with the cardinal directions. You drive 2 miles north on the Strip, turn right on Flamingo at the Harley-Davidson Cafe, drive east 3 miles to Maryland, turn south on Maryland and drive 1 mile to Tropicana, and, finally, turn right on Tropicana and drive 3 miles. Where are you? How many miles have traveled? What is your total **DISPLACEMENT**? **HINT:** Draw a diagram.

   a) On the Strip (at the MGM Grand for what it's worth), 9 miles, and **1 MILE**.
   b) On the Strip (at the MGM Grand for what it's worth), 9 miles, and **1 MILE NORTH**.
   c) On the Strip (at the MGM Grand for what it's worth), 1 mile, and **9 MILES NORTH**.
   d) On the Strip (at the MGM Grand for what it's worth), 1 mile, and **9 MILES**.
   e) On the Strip (at the Hard Rock Cafe), 9 miles, and **9 MILES**.

SUGGESTED ANSWER: (b)

This is the trick question since its so tempting to stop at answer (a).

Ah, I remember the corner well from my days in Vegas working at UNLV (1998–1999). This question might take too long on a 5 minute quiz just to read it out when the students are only half awake and frazzled. Just remember that displacements are vectors and so you need to provide a direction.

Wrong answers:
a) One mile is the magnitude only of the displacement.
c) This would put you north of Cashman Field I think.
d) Nine miles isn't even the magnitude of the displacement.
e) You are not at the Hard Rock Cafe which isn't even on the Strip: its on Harmon East. (But doesn't it have a strip entrance?) But you didn't need to know that to know the answer is wrong.

Redaction: Jeffery, 2001jan01

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002 qmult 00532 1 3 2 easy math: average speed on round trip: Knoxville 2

Extra keywords: a round trip to Knoxville

7. You have just traveled at total distance of 400 km on a trip to Knoxville and back. It took 8 hours. Your average **SPEED** was:

a) 0 km/h. b) 50 km/h. c) 100 km/h. d) 200 km/h. e) 400 km/h.

SUGGESTED ANSWER: (b) An easy math question. This is the lead in to an average velocity question.

Wrong answers:
a) This is your average velocity.

Redaction: Jeffery, 2008jan01

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002 qmult 00600 1 4 5 easy deducto-memory: acceleration defined

8. "Let's play *Jeopardy*! For $100, the answer is: It is the rate of change of velocity with respect to time. It is important to note that it is a vector and since velocity is a vector, the quantity is non-zero if velocity changes in either or both magnitude and direction."

What is ____________, Alex?

a) time b) force c) displacement d) velocity e) acceleration

SUGGESTED ANSWER: (e)

Wrong answers:
a) As Lurch would say AAAARGH.

Redaction: Jeffery, 2012jan01

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002 qmult 00700 1 1 4 easy memory: inertial frame defined

9. A/An ____________ is a physics defined frame of reference in which accelerations are caused by forces. In modern theory, this kind of frame is **NOT** accelerated relative to the local frame that participates in the mean expansion of the universe.

a) accelerated frame b) rotating frame c) non-inertial frame
d) inertial frame e) decelerated frame

SUGGESTED ANSWER: (d)

Wrong answers:
c) Exactly wrong.

Redaction: Jeffery, 2012jan01

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002 qmult 00810 1 5 3 easy thinking: what forces do

10. Forces can cause accelerations relative to inertial frames or cancel other forces. Another manifestation (which actually follows from their property of causing acceleration) is that they can cause:

a) velocity (without causing acceleration).) mass.
c) bodies to distort: i.e., flex, compress, stretch, etc. d) bodies to live.
e) bodies to rule.

SUGGESTED ANSWER: (c)

Forces do so much that with suitable qualification almost anything can be a predicate here. But in a definitional general sense "cause acceleration relative to inertial frames" and "cancel other forces" are the main properties. They also distort bodies. This is not really an independent property of force. If accelerations of a body happen relative to other parts of a body, then there will be deformations. Constant velocity deformations can happen too, but an acceleration was needed to create the velocity doing the deforming in the first place.

If we don't see either an acceleration or a distortion, then how do we know or measure force? Well we often use the 2nd or 3rd law in cases where acceleration zero and distortion is invisible: but distortion is there even if we don't see it. For instance, the normal force of a macroscopically rigid body may not manifest itself either way. But there is a microscopic distortion with the normal force surface nonetheless.

Wrong answers:
a) This is one thing they don't cause. You could twist the meaning of the words to make it true, but it would just be a twisted case.
b) Arguable in some far-out high energy physics way.
d) Again sure, but they don't have to.
e) Nonsense answer.

Redaction: Jeffery, 2001jan01

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002 qmult 01010 1 1 4 easy memory: center of mass definition 2

11. The center of mass is the:

a) position-weighted mean mass of the an object.
b) object-weighted mean mass of the position.
c) mean of mass an weighted object position of.
d) mass-weighted mean position of an object.
e) simple center of the object.

SUGGESTED ANSWER: (d)

For most objects, one really needs to do a integration of position weighted by density to find the center of mass.

Wrong answers:

c) Word jumble.
e) Simple center has no precise physics definition.

Redaction: Jeffery, 2001jan01

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002 qmult 01020 1 4 2 easy deducto-memory: center of mass, reference frame

12. The center of mass (i.e., the actual physical position of the center of mass in space relative to the physical system it is the center of mass of) is:

a) a function of the coordinate system.
b) independent of the coordinate system.
c) dependent on the coordinate system.
d) both independent of and a function of the coordinate system.
e) neither independent of nor a function of the coordinate system.

SUGGESTED ANSWER: (b)

Wrong answers:

a) Absolutely wrong.
c) Absolutely wrong and meaning the same thing as answer (a).
d) Not logically possible.
e) Not logically possible again.

Redaction: Jeffery, 2001jan01

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002 qmult 01042 1 4 5 easy deducto-memory: cm at geometric center 2

13. If an object is symmetric in 3 dimensions about some point (i.e., its geometric center), its center of mass must be:

a) outside of the object.
b) neither inside nor outside the object.
c) at the point about which the object is symmetric in 2 of the dimensions, but not in the 3rd.
d) at the point about which the object is symmetric in 1 of the dimensions, but not in the other 2.
e) at the geometric center.

SUGGESTED ANSWER: (e)

Wrong answers:

a) Centers of mass can be outside of bodies, but they don't have to be in general nor for objects symmetric in 3 dimensions.

Redaction: Jeffery, 2001jan01

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002 qmult 01052 1 5 5 easy thinking: hanger center of mass

14. Where, roughly speaking, is the center of mass of a coat hanger? **HINT:** Imagine letting it hang from two different free pivot points: this is called a Gedanken (thought) experiment in physics speak. If you arn't in a test *mise en scène*, you could actually do the experiment.

    a) At the end of the hook.
    b) At the top of the hook.
    c) At the left end of the triangular loop.
    d) Nowhere since a center of mass must be physically inside an object to be a center of mass.
    e) Oh, somewhere not so far from the middle region of the triangular loop.

    SUGGESTED ANSWER: (e)

    Wrong answers:
    c) What if the left side of a hanger? The one to which the hook grabs or the other? Maybe Charles Dodgson would know.

    Redaction: Jeffery, 2001jan01

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002 qmult 01120 2 4 3 moderate deducto-memory: inertial frames

15. Velocity and acceleration in, respectively, Newton's 1st and 2nd laws of motion are referenced to:

    a) rotating frames. b) accelerated frames. c) inertial frames.
    d) non-inertial frames. e) picture frames.

    SUGGESTED ANSWER: (c)

    Wrong answers:
    d) Exactly wrong.
    e) Oh, c'mon.

    Redaction: Jeffery, 2001jan01

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002 qmult 01132 1 1 3 easy memory: the number of Newton's laws 2
Extra keywords: physci

16. Newton once thought about having six laws of motion (or so the instructor seems to recall), but eventually settled on:

    a) one. b) two. c) three. d) four. e) three and half.

    SUGGESTED ANSWER: (c)

    I seem to recall Newton thought about specifying 6 laws, but concluded that laws that were only obeyed in special cases or approximately couldn't be laws and worked his way down to three thereby starting a trend: three laws of thermodynamics, three laws of robotics, etc. Of course, when there turned out to be four laws in both thermo and robo, one just calls the fourth law, the zeroth law. And actually, Newton's 1st law is a special case of his 2nd law: logically one only needs the 2nd and 3rd laws. However, the 1st law is historical and also pedagogically useful, and so maintains its dignity as a law.

Wrong answers:

b) Actually, the 1st law is a special case of the 2nd law, and so logically there are really only two laws, but Newton said three and three it has remained. Since Newton was a heretical unitarian (unless I'm misremembering again), he couldn't have been trying to have a trinity.

e) Oh, c'mon.

Redaction: Jeffery, 2001jan01

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002 qmult 01152 1 1 1 easy memory: Newton's 2nd law: 2

17. Newton's 2nd law is:

a) $\vec{F} = m\vec{a}$. b) $m\vec{F} = \vec{a}$. c) $E = mc^2$. d) $E = mc^3$. e) $m = Ec^2$.

SUGGESTED ANSWER: (a)

Wrong answers:

c) This is the Einstein equation.

Redaction: Jeffery, 2008jan01

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002 qmult 01156 1 1 5 easy memory: net external forces and center of mass

Extra keywords: anticipates later chapters, but that's OK

18. If you know nothing about the internal forces of a body and only know the net external force that acts on the body and not where on the body the particular external forces act, then, by itself, Newton's 2nd law for a non-point mass only allows you to predict:

a) the **VELOCITY** of the body.
b) the **VELOCITY** of the center of mass of the body. You can know nothing about internal motions of the body or its rotational behavior.
c) the **ACCELERATION** of the top point of the body.
d) the **ACCELERATION** of the bottom point of the body.
e) the **ACCELERATION** of the center of mass of the body. You can know nothing about internal motions of the body or its rotational behavior.

SUGGESTED ANSWER: (e)

Wrong answers:

a) Oh c'mon.

Redaction: Jeffery, 2001jan01

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002 qmult 01162 1 5 1 easy thinking: acceleration and third law

Extra keywords: also physci KB-59-15

19. If Newton's 3rd law is true, why then does anything accelerate at all?

a) The equal and opposite forces **DO NOT** have to be on the same body.
b) The equal and opposite forces **DO** have to be on the same body.
c) Nothing moves at all as Parmenides argued in the 5th century BC. Motion is but seeming. Anyway Parmenides seems to have been a pretty smart guy since he's credited with the spherical Earth theory and the discovery that the Moon shines by reflected light.

d) Acceleration has nothing do with forces.
e) Forces have nothing do with acceleration.

SUGGESTED ANSWER: (a) I've provided some leading answers.

Wrong answers:
b) Straight nonsense, since it leads to the opposite conclusion.
c) Parmenides was not really saying that nothing moves at all. He was just arguing from certain premises which he did not necessarily affirm. Actually it is hard to quite know for sure about the big P, since his own words only survive in fragments from his poem in which he lets the unnamed goddess speak for him in oracular manner. Shortly after Parmenides, natural philosophers gave up on poetry and the two have seldom overlapped since. Omar Khayyam (if he really was a poet) and Chaucer (really more of popularizer of science than a practitioner) are possible cases. See D. Furley, "The Greek Cosmologists", p. 36 ff, esp. 41.

Redaction: Jeffery, 2001jan01

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002 qmult 01230 1 1 1 easy memory: normal force calculation

20. A uniform pillar of density ρ, height h, and horizontal area A has normal force ____________ at a height y above the ground.

a) $(h-y)A\rho$ b) $yA\rho$ c) $(y/A)\rho$ d) $(h-y)/A]\rho$ e) $1/(yA\rho)$

SUGGESTED ANSWER: (a)

Wrong answers:
b) Poor guess.

Redaction: Jeffery, 2012jan01

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002 qmult 01250 1 3 5 easy math: F=ma to find a brick's mass to find a force
Extra keywords: physci KB-60-23

21. A 50 N net force gives a brick an acceleration of 5 m/s. What net force is need to give it an acceleration of 10 m/s?

a) 50 N. b) 5 N. c) 10 N. d) 200 N. e) 100 N.

SUGGESTED ANSWER: (e)

The brick's mass is invariant one assumes. Thus, by $F_{\text{net}} = ma$, the acceleration is proportional to the net force. If the acceleration is doubled, so the force must be doubled. Incidentally, the mass of the brick is 10 kg.

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

Redaction: Jeffery, 2001jan01

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002 qmult 01344 1 3 2 easy math: falling in 4 seconds

22.* How far does a person fall in 4 s starting from **REST**? (Neglect air drag.)

a) 39.2 m. b) 78.4 m. c) 9.8 m. d) 156.8 m. e) From the Earth to the Moon.

SUGGESTED ANSWER: (b)

Use the kinematic equation

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

to find

$$\Delta y = \frac{1}{2}gt^2 = 4.9 \times 16 = 78.4\,\mathrm{m}\ .$$

Wrong answers:
e) This is the title of a Jules Verne story.

Redaction: Jeffery, 2008jan01

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002 qmult 01362 1 2 3 easy deduction: human terminal velocity 2
Extra keywords: physci

23. What is approximately the terminal velocity of a human in air? **HINT:** You don't have to know the answer; you can deduce it.

a) 10 km/h. b) 1 km/h. c) 200 km/h. d) 0.1 km/h. e) 3×10^5 km/s.

SUGGESTED ANSWER: (c)

The students have to be clear that 1 mi/h is very roughly about 2 kilometers per hour. They have to realize that you don't hit the ground very hard at 10 km/h. This is just a bit faster than ordinary walking speed.

Wrong answers:
a) This is a hard, but not deadly, hitting speed.
b) This is isn't even hard.
d) This is soft.
e) This is the speed of light. Students have to at least recognize this is faster than anything they see fall.

Redaction: Jeffery, 2001jan01

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

24. "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

25. 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 $g = 9.8\,\mathrm{m/s^2}$.

Wrong answers:

Redaction: Jeffery, 2001jan01

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002 qmult 01420 1 1 3 easy memory: momentum is not energy
Extra keywords: physci KB-93-15

26. Linear momentum is **NOT**:

a) a physical quantity. b) dependent on velocity. c) a kind of energy.
d) dependent on mass. e) given by $p = mv$ for one-dimensional cases.

SUGGESTED ANSWER: (c)

Momentum is closely related to kinetic energy. The two both calculated from mass and velocity, but momentum is not energy. For one thing, momentum is a vector and energy is a scalar.

Wrong answers:

e) But it is so given.

Redaction: Jeffery, 2001jan01

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002 qmult 01450 1 1 2 easy memory: conservation of momentum, Thor
Extra keywords: physci

27. The mighty Thor is trapped in the eternal vacuum of gravity-free space with nothing to push on. But he sees Asgard glittering **YONDER** (i.e., over there). Having taken

introductory physics in his young Viking days, he realizes that he will soar straight to Asgard if, with awesome strength, he throws his hammer:

a) yonder. b) anti-yonder. c) any which way. d) left.
e) in a parabolic arc.

SUGGESTED ANSWER: (b)

Wrong answers:
e) Not in gravity-free space.

Redaction: Jeffery, 2001jan01

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

28. 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 01522 1 1 4 easy memory: conservation of energy 2
Extra keywords: physci

29. In the physics, the conservation of energy means energy:

a) shouldn't be wasted on cars. b) is never destroyed.
c) is never created. d) is never created or destroyed.
e) is perpetually created.

SUGGESTED ANSWER: (d)

Wrong answers:
e) Well no.

Redaction: Jeffery, 2001jan01

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

30. 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 01604 1 1 3 easy memory: work formula for a constant force 2
Extra keywords: For the vector and dot product literate

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

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

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

32. 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

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

The work done by the lifting force is

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

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

33. 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 01652 2 5 2 moderate math: friction killing KE 2

Extra keywords: physci KB-95-9

34. A moving object initially has $KE = 200$ J and slides to a stop on a horizontal surface. How much work has been done by gravity, the normal force, and the friction force?

a) 0, 0, 200 J. b) 0, 0, -200 J. c) 9.8 J, -9.8 J, 200 J.
d) 9.8 J, -9.8 J, -200 J. e) -9.8 J, 9.8 J, 200 J.

SUGGESTED ANSWER: (b)

Gravity and the normal force do no work since they are perpendicular to the displacement direction. Since the object comes to rest, negative work must be done on it and friction is the only force that could have done it. To reduce 200 J of kinetic energy to zero, one needs -200 J of friction work.

Wrong answers:

e) Not a good guess.

Redaction: Jeffery, 2001jan01

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

35. "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 01724 1 1 1 easy memory: conservation of mechanical energy 2

36. Interpreting the symbols in the most **STRAIGHTFORWARD WAY** and without mental qualifications (e.g., this is really the inverse or the absolute value of a quantity or a change in a quantity or this is for a special case), the formula for conservation of mechanical energy for a particle or a system that can be treated as a particle (i.e., is described by its center of mass behavior) is:

a) $\Delta KE = -\Delta PE$. b) $\Delta KE = \Delta PE$. c) $KE = PE$.
d) $KE = 1/PE$. e) $\Delta KE = -1/\Delta PE$.

SUGGESTED ANSWER: (a)

Wrong answers:

a) If you make the mental qualification that ΔPE is the additive inverse of the change in potential energy, then this formula is valid. No one looking at it without knowing that qualification would say it was correct.
b) If you make the mental qualification that PE is potential energy of the system when all its energy is potential energy and KE is the potential energy of the system when all its energy is kinetic energy, then this formula is valid. No one looking at it without knowing that qualification would say it was correct.

Redaction: Jeffery, 2008jan01

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002 qmult 01732 1 3 3 easy math: dog drops brick mech. energy conserved 2

Extra keywords: physci

37. A brick has mass 2.0 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) 2.0 m. The brick started from rest and air drag is negligible. What is the kinetic energy of the brick just before it hits the ground?

a) 9.8 J. b) 19.6 J. c) 39.2 J. d) about 50 J. e) about 160 J.

SUGGESTED ANSWER: (c)

From the work-energy theorem

$$\Delta E = W_{\text{non}} \ ,$$

one obtains

$$KE = KE_0 - \Delta PE + W_{\text{non}} = 0 - mg\Delta y + 0 = 39.2\,\text{J} \ ,$$

where $KE_0 = 0$, $\Delta y = -2.0\,\text{m}$, and $W_{\text{non}} = 0$.

Wrong answers:
d) Well no.

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

38. 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 02032 1 3 3 easy math: gravity force calculation

39. Using Newton's gravitation law

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

($G = 6.67384(80) \times 10^{-11}\,\mathrm{N\,m^2/kg^2}$: 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 02110 1 1 3 easy memory: free fall in orbit

40. 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

001 qfull 00310 1 3 0 easy math: describe Eratosthenes measurement

41. Describe Eratosthenes's measurement of the circumference of the Earth. In particular, discuss how his measurement was theory-laden: i.e., how it assumed certain theories in order to have the meaning that it did. You should use diagrams. Knowing the numbers Eratosthenes used is not needed. You have to describe the method. Write legibly.

SUGGESTED ANSWER:

Eratosthenes (c. 276–c. 195 BCE) noted that on the summer solstice at noon the Sun was directly overhead (i.e., at zenith) in Syene which was due south of Alexandria where he lived. Therefore, a ray from the Sun to Syene can be extended to the Earth's center assuming the Earth is a sphere. (Syene is approximately on the Tropic of Cancer. It is modern-day Aswan in Egypt.) In Alexandria at that time, the Sun was small angle θ away from zenith, and therefore cast shadows of finite length. The angle of the Sun from zenith is from geometry also the angle that a radius from the Earth's center to Alexandria makes with the ray through Syene. From the geometry of a circle, one has

$$\frac{\theta}{360^\circ} = \frac{s}{C} \ ,$$

where s is the arc length distance between Syene and Alexandria and C is the circumference of the Earth. Thus, we find that

$$C = \frac{360^\circ}{\theta} s \ .$$

Now Eratosthenes measured $\theta = 7.2^\circ$ and estimated $s = 5000$ stadia (which is about 800 km). Thus,

$$C = 2.5000 \times 10^5 \text{ stadia} = 39375 \text{ km} \ ,$$

which is only $-1.6\,\%$ less than the modern meridional circumference of 40,007.86 km. We have had to assume the Erastothenes used the Egyptian stadion which is about 0.1575 km rather than the Attic stadion of about 0.185 km—heck, he lived in Egypt, not an attic after all.

The above explanation would be aided by the diagram that you must imagine for yourself.

Eratosthenes's measurement is theory-laden in that he relied on Euclidean geometry and on the theory that the Earth was round. Euclidean geometry certainly describes our physical space to high accuracy. (Eratosthenes may well have known Euclid (fl. 300 BCE) who also lived in Alexandria.) The round Earth theory was essential. If the Earth was not round, the circumference value Eratosthenes obtained would have no clear meaning. It could have no meaning at all for the actual dimensions of a non-round Earth or it could have been some characteristic size scale for roundish Earth.

The round Earth theory dates back to about the 5th century BCE and may have been first based on the fact that the shadow of the Earth on the Moon in lunar eclipses is always round. A round object always casts a round shadow and a non-round object only in some cases. The original proposer may have been Parmenides (fl. early 5th century BCE), or Pythagoras (c. 570–c. 495 BCE) or his early followers.

Fortran-95 Code

```
      print*
      cc=(360.d0/7.2d0)*5000.d0
      cckm=cc*.1575d0  ! .1575 Egyptian stadia to the km
      ccearth=40007.86d0  ! meridional circumference
      print*,'cc,cckm,(cckm-ccearth)/ccearth'
      print*,cc,cckm,(cckm-ccearth)/ccearth
! cc,cckm,(cckm-ccearth)/ccearth
!   250000.00       39375.000     -1.58183761E-02
```

Redaction: Jeffery, 2012jan01

EXTRA ANSWER PAGE

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