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
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10.	O	O	O	O	O
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13.	O	O	O	O	O
14.	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
32.	O	O	O	O	O
33.	O	O	O	O	O
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42.	O	O	O	O	O
43.	O	O	O	O	O
44.	O	O	O	O	O
45.	O	O	O	O	O
46.	O	O	O	O	O
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58.	O	O	O	O	O
59.	O	O	O	O	O
60.	O	O	O	O	O

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.

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) $9.8\,\mathrm{N/kg}$

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) $1.62\,\mathrm{N/kg}$. b) $4.2\,\mathrm{N/kg}$. c) $7.8\,\mathrm{N/kg}$. d) $8.8\,\mathrm{N/kg}$. e) $9.8\,\mathrm{N/kg}$.

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

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) $29.4\,\mathrm{m/s}$. b) $44.1\,\mathrm{m/s}$. c) $9.8\,\mathrm{m/s}$. d) $88.2\,\mathrm{m/s}$. e) At the speed of light.

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.

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

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.

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 $\sim 20\,\mathrm{m}$ 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

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

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.

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.

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) $\vec{p} = m\vec{v}$.

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.

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.

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.

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

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

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) $E = KE + PE$.

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.

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) $\mathrm{M/T^2}$.

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).

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

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

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

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) $dW = \vec{F} \times d\vec{s}$.

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) $W = \vec{F} \cdot \Delta\vec{r} \cdot \Delta\vec{r}$.

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.

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.

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.

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.

32. The work-kinetic-energy theorem is:

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

33. A moving object has initial $KE = 100$ J and is subjected to a friction force of magnitude 2 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.

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.

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.

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?

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.

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

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.

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.

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

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

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.

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.

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.

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)

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

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.

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) $\vec{F}_{12} = -Gm_1m_2r^2\hat{r}_{12}$. 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) $\vec{F}_{12} = -\dfrac{Gm_1m_2}{r^2}\hat{r}_{12}$. e) $\vec{F}_{12} = -\dfrac{Gm_1m_2}{r^3}\hat{r}_{12}$.

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.

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) $6.67384(80) \times 10^{-11}$

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}.

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.

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 $y/9$.

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.