SOLUTIONS

Physics 151
May 16, 2008

Score: **100 pts. possible**

PHYS 151 Final Exam (with errors corrected)

Exam time limit: 120 minutes. You may use a calculator and both sides of TWO sheets of notes, *handwritten only*. Closed book; no collaboration.

Complete *ALL* questions. For each multiple choice question, choose the ONE best answer. There is no penalty for guessing.

Ignore friction and air resistance in all problems, unless told otherwise.

On your **BUBBLE SHEET**, please fill in: **"Last Name, First Name"** = your name
"Identification Number" = your ROSTER number for PHYS 151
NO other fields (birthdate, grade, etc.) are necessary.

Physical constants:
$g = 9.80\ \text{m/s}^2$
$N_A = 6.022 \times 10^{23}\ \text{mol}^{-1}$
$G = 6.674 \times 10^{-11}\ \text{N·m}^2/\text{kg}^2$
$k_B = 1.381 \times 10^{-23}\ \text{J/K}$
$R = 8.314\ \text{J/(mol·K)} = 0.0821\ \text{L·atm/(mol·K)}$

Useful conversions:
1 year = 3.156×10^7 s
1 cal = 4.186 J
1 m^3 = 1000 L
0°C = 273.15 K
1 atm = 1.013×10^5 Pa

masses	*radii*	*orbital distances*	*orbital periods*
$M_{\text{Sun}} = 1.99 \times 10^{30}$ kg	$R_{\text{Sun}} = 6.96 \times 10^8$ m		
$M_{\text{Earth}} = 5.97 \times 10^{24}$ kg	$R_{\text{Earth}} = 6.38 \times 10^6$ m	$r_{\text{Earth-Sun}} = 1.50 \times 10^{11}$ m	$T_{\text{Earth}} = 1.00$ year
$M_{\text{Moon}} = 7.35 \times 10^{22}$ kg	$R_{\text{Moon}} = 1.74 \times 10^6$ m	$r_{\text{Earth-Moon}} = 3.84 \times 10^8$ m	$T_{\text{Moon}} = 27.3$ days

(2 pts. each) **Convert** the following quantities into the specified units:

1. 660 kW = ____________________ GW
A. 6.6×10^{-8} GW
B. 6.6×10^{-7} GW
C. 6.6×10^{-5} GW
[✓ D. 6.6×10^{-4} GW]
E. 0.66 GW

$$\left(660\,\cancel{\text{kW}}\right)\left(\frac{1000\,\cancel{\text{W}}}{1\,\cancel{\text{kW}}}\right)\left(\frac{1\ \text{GW}}{10^9\,\cancel{\text{W}}}\right) = \underline{\underline{6.6\times10^{-4}\ \text{GW}}}$$

2. 720 μL = ____________________ cm^3
A. 7.2×10^{-4} cm^3
B. 7.2×10^{-2} cm^3
[✓ C. 0.72 cm^3]
D. 72 cm^3
E. 720 cm^3

$$\left(720\,\cancel{\mu\text{L}}\right)\left(\frac{10^{-6}\,\cancel{\text{L}}}{1\,\cancel{\mu\text{L}}}\right)\left(\frac{10^3\ \text{cm}^3}{1\,\cancel{\text{L}}}\right) = \underline{\underline{0.72\ \text{cm}^3}}$$

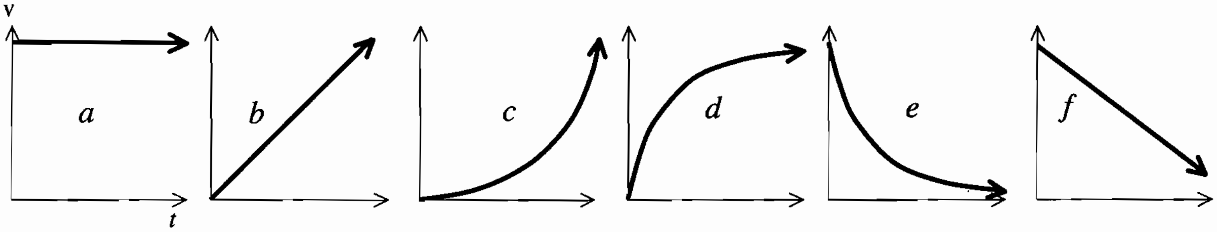
3. 3.0 km^3 = ____________________ mm^3
A. 3.0×10^6 mm^3
B. 3.0×10^9 mm^3
C. 3.0×10^{12} mm^3
D. 3.0×10^{15} mm^3
[✓ E. 3.0×10^{18} mm^3]

$$\left(3.0\,\cancel{\text{km}^3}\right)\left(\frac{10^3\,\cancel{\text{m}}}{1\,\cancel{\text{km}}}\right)^3\left(\frac{1\ \text{mm}}{10^{-3}\,\cancel{\text{m}}}\right)^3 = \underline{\underline{3.0\times10^{18}\ \text{mm}^3}}$$

4. 55,000 km/s = ____________________ μm/ns
A. 5.5×10^7 μm/ns
[✓ B. 5.5×10^4 μm/ns]
C. 55 μm/ns
D. 5.5×10^{-2} μm/ns
E. 5.5×10^{-5} μm/ns

$$\left(55{,}000\,\frac{\cancel{\text{km}}}{\cancel{\text{s}}}\right)\left(\frac{10^3\,\cancel{\text{m}}}{1\,\cancel{\text{km}}}\right)\left(\frac{1\ \mu\text{m}}{10^{-6}\,\cancel{\text{m}}}\right)\left(\frac{10^{-9}\,\cancel{\text{s}}}{1\ \text{ns}}\right) = 55{,}000\,\frac{\mu\text{m}}{\text{ns}}$$

$$= \underline{\underline{5.5\times10^4\,\frac{\mu\text{m}}{\text{ns}}}}$$



Each of the graphs shown here represents the **VELOCITY** for a different car as a function of time. (Each car is constrained to move only along the *x*-axis.)

5. (1 pt.) Which of the cars has/have a **constant speed** during the *entire* time period shown?

[✓ A.] *a* only
B. *b* only
C. *f* only
D. *a* & *b*
E. *b* & *f*

graph of constant v ⇒ horizontal graph (slope = 0)

6. (1 pt.) Which of the cars has/have a **constant acceleration** (including zero) during the *entire* time period shown?

A. *a* only
B. *b* only
C. *f* only
D. *a* & *b*
[✓ E.] *a*, *b*, & *f*

accel = slope of v vs. t graph
∴ constant a ⇒ graph with constant slope (straight line)

7. (2 pts.) Which of the cars has/have **negative acceleration** during the *entire* time period shown?

A. *e* only
B. *f* only
[✓ C.] *e* & *f*
D. *d*, *e*, & *f*
E. none

accel = slope of v vs. t graph
∴ negative a ⇒ graph with negative slope

8. (2 pts.) Which of the cars is/are **slowing down** during the *entire* time period shown?

A. *d* only
B. *e* only
C. *d* & *e*
[✓ D.] *e* & *f*
E. *d*, *e*, & *f*

Slowing down ⇒ v getting closer to zero at all times.

Visiting the circus…

A "human cannonball" acrobat ($m = 55$ kg) is launched straight up, starting from ground level. (Ignore air resistance.) The cannonballer wants to rise to a height of exactly 15.0 m, so that he can grab onto a mid-air platform at the very peak of his arc.

9. (2 pts.) What **initial velocity** should the cannonballer use at launch?

A. 13.3 m/s
B. 15.7 m/s
[✓ C.] 17.1 m/s
D. 19.5 m/s
E. 21.9 m/s

$v_f^2 = v_0^2 + 2\cdot a\cdot \Delta y$

at peak: $0 = v_0^2 + 2\cdot(-g)\cdot\Delta y$

$\Rightarrow v_0 = \sqrt{2\cdot g\cdot\Delta y} = \sqrt{2\cdot(9.80\,\text{m/s}^2)(15.0\,\text{m})}$

$= 17.1\,\text{m/s}$

10. (2 pts.) How much **time** does it take the cannonballer to ascend?

[✓ A.] 1.7 s
B. 2.0 s
C. 2.4 s
D. 2.7 s
E. 3.1 s

$v_f = v_0 + a\cdot t$

at peak: $0 = v_0 + (-g)t$

$\Rightarrow t = \frac{v_0}{g} = \frac{17.1\,\text{m/s}}{9.80\,\text{m/s}^2} = 1.75\,\text{s}$

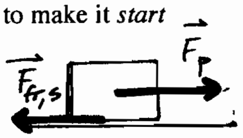
11. (2 pts.) All of the following quantities are **constant** during flight (from just after launch until just before grabbing onto the platform) **EXCEPT** which one?

A. weight of cannonballer $= m\cdot g$ = constant
B. net force acting on cannonballer $= m\cdot g$ = constant
C. acceleration of cannonballer $= g$ = constant
[✓ D.] momentum of cannonballer $= m\cdot v$ ⇒ decreases!
E. total mechanical energy of cannonballer $= K + U_{gr} = \frac{1}{2}mv^2 + m\cdot g\cdot y$ = constant.

You want to slide a heavy 95-kg desk along a level floor that has a coefficient of static friction $\mu_s = 0.75$.

12. (2 pts.) If the desk is at rest, what is the **minimum horizontal force** you must apply to the desk to make it *start* sliding?

A. 330 N
B. 590 N
[✓ C. 700 N]
D. 930 N
E. 1200 N



$F_p = F_{fr(max)}$

$= \mu_s \cdot F_G$

$= \mu_s \cdot m \cdot g = (0.75)(95\text{ kg})(9.80\text{ m/s}^2) = \underline{\underline{698\text{ N}}}$

13. (2 pts.) Once the desk is in motion, you find that you must apply a horizontal force on the desk of 330 N to push it at a *constant speed.* What is the **coefficient of kinetic friction** between the desk and the floor?

A. 0.28
[✓ B. 0.35]
C. 0.39
D. 0.44
E. 0.50

$F_p = F_{fr,k}$

$= \mu_k \cdot F_G$

$F_p = \mu_k \cdot m g$

$\Rightarrow \mu_k = \frac{F_p}{mg} = \frac{330\text{N}}{(95\text{kg})(9.80\text{ m/s}^2)}$

$\underline{\underline{\mu_k = 0.354}}$

14. (2 pts.) If you push the desk at a *constant speed* through a distance of 5.8 m, how much **work** have you done?

A. none
[✓ B. 1.9 kJ]
C. 2.8 kJ
D. 3.6 kJ
E. 5.4 kJ

$W = F_p \cdot d \cdot \cos\phi$

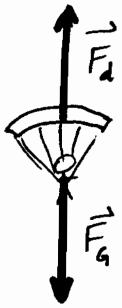
$= (330\text{ N})(5.8\text{ m})(\cos 0°)$

$= 1914\text{ J} \approx \underline{\underline{1.9 \times 10^3\text{ J}}}$

Suppose that your mass is 85 kg. You go skydiving, and while parachuting downward toward the earth, you find yourself descending at a *constant speed* of 14 m/s.

15. (2 pts.) What is the total **drag force** of the air (on you and your parachute)?

A. 140 N
B. 410 N
C. 690 N
[✓ D. 830 N]
E. 1200 N



constant $v \Rightarrow a_y = 0$

$\Rightarrow \Sigma F_y = 0$

$F_d = m \cdot g$

$= (85\text{ kg})(9.80\text{ m/s}^2)$

$= \underline{\underline{833\text{ N}}}$

16. (2 pts.) During this time period, you experience…

A. zero weight ($\underline{\text{no}}$: $F_G = m \cdot g$ always)
B. negative (downward) acceleration ($\underline{\text{no}}$: $a_y = 0$)
C. negative (downward) net force ($\underline{\text{no}}$: $\Sigma F_y = 0$)
[✓ D. constant momentum] ($\underline{\text{yes}}$: $p = m \cdot v$, and $v =$ constant)
E. increasing kinetic energy ($\underline{\text{no}}$: $K = \frac{1}{2} m v^2 =$ constant)

Back to the circus again…

17. (2 pts.) Elsewhere at the circus, the Amazing Octuplets (eight identical sisters, each with the same mass *M*) are attempting an aerial balancing feat: a lightweight but strong beam (length *L* = 5.0 m, *negligible* mass) is suspended by a strong cable at a position *x* = 1.5 m from one end. Five of the sisters all sit on the beam together at the position *x* = 0, while two of them sit together at position *x* = 5.0 m. **Where** should the last sister **position** herself so that the beam will balance when it is suspended?

A. *x* = 0.80 m
B. *x* = 1.2 m
[✓ C. *x* = 2.0 m]
D. *x* = 2.5 m
E. *x* = 3.3 m

$\underline{\underline{\text{center-of-mass}}}$:

$x_{cm} = \frac{m_1 x_1 + m_2 x_2 + m_3 x_3}{m_1 + m_2 + m_3}$

fulcrum location: ↓

$1.5\text{m} = \frac{(5M)(0) + (2M)\cdot(5.0\text{m}) + (M)x_3}{8M}$

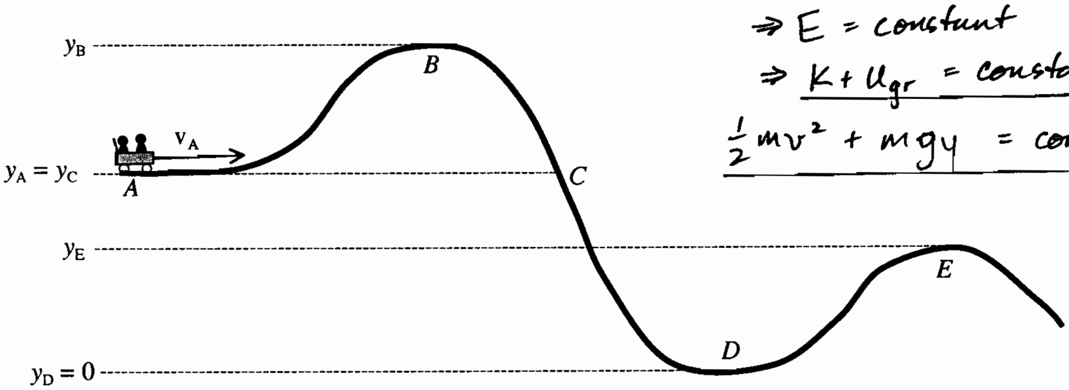
$\Rightarrow \underline{\underline{x_3 = 2.0\text{ m}}}$

no friction

$\Rightarrow E = \text{constant}$

$\Rightarrow \underline{K + U_{gr} = \text{constant}}!$

$\underline{\frac{1}{2}mv^2 + mgy = \text{constant}}.$



Consider a roller coaster car that rolls *frictionlessly* along the entire track shown above. The car has initial velocity v_A at point *A*.

18. (1 pt.) At which point does the car have its **greatest kinetic energy**?

A. *A*
B. *B*
C. same at all points
[✓ D.] *D*
E. cannot determine using the information given

$K + U_{gr} = \text{constant}$
$\Rightarrow K$ is largest when U_{gr} is smallest
$\Rightarrow$ when $\underline{y}$ is lowest.

OR: $K = \frac{1}{2}mv^2$, and we know intuitively that v is greatest at lowest point.

19. (1 pt.) If points *A* and *C* are at the *same height*, then the car's **speed at point *C*** must be…

A. less than v_A
[✓ B.] equal to v_A
C. greater than v_A
D. cannot determine using the information given

$$E_A = E_C$$

$$\frac{1}{2}mv_A^2 + mgy_A = \frac{1}{2}mv_C^2 + mgy_C$$

Since $y_A = y_C$, we must have $\underline{v_A = v_C}$.

As the car passes through point *B*, its kinetic energy is 12 kJ. Later as the car passes through point *D*, its kinetic energy is 97 kJ, and its potential energy is zero. The car's mass is 440 kg.

20. (2 pts.) Knowing that $y_D = 0$, what is the **height of point *B*, y_B**?

[✓ A.] 20. m
B. 28 m
C. 37 m
D. 46 m
E. 54 m

$$E_B = E_D$$

$$K_B + (U_{gr})_B = K_D + (U_{gr})_D$$

$$12\text{ kJ} + mgy_B = 97\text{ kJ} + 0$$

$$(440\text{kg})(9.80\text{m/s}^2)\,y_B = 85{,}000\text{ J} \Rightarrow \underline{y_B = 19.7\text{m}}$$

21. (1 pt.) The car's **total mechanical energy** at point *A* is ____________ its total mechanical energy at point *E*.

A. less than
[✓ B.] equal to
C. greater than
D. cannot determine using the information given

$E_A = E_E = \text{constant}!$

22. (1 pt.) Suppose that y_A is 6.0 m higher than y_E. Then, the **difference in speeds** between v_A and v_E is:
(*Warning: This one is tricky!*)

A. 3.3 m/s
B. 3.8 m/s
C. 4.2 m/s
D. 4.7 m/s
[✓ E.] cannot determine using the information given

---

23. (1 pt.) If there is some *friction* along the track, then the car's **total mechanical energy** at point *A* will be ____________ its total mechanical energy at point *E*.

A. less than
B. equal to
[✓ C.] greater than
D. cannot determine using the information given

with friction, $E = (K + U_{gr})$ decreases over time.

$\Rightarrow E_A > E_E$.

A 45-gram air-hockey puck glides frictionlessly on an air-hockey table. Before being struck by a player's paddle, the puck's speed is 0.55 m/s *to the left*. As it is hit, the puck receives a total *impulse* of 0.15 kg·m/s *to the right*. (Assume that the puck moves only along the one-dimensional x-axis.)

Let $(+)$ be $\underline{\text{to right}}$.

$$\overset{\text{impulse}}{\Delta p} = p_f - p_i$$

$$\Delta p = m v_f - m v_i$$

$$0.15\ \tfrac{\text{kg}\cdot\text{m}}{\text{s}} = (0.045\,\text{kg})\,v_f - (0.045\,\text{kg})(-0.55\ \tfrac{\text{m}}{\text{s}})$$

$$\Rightarrow \underline{v_f = 2.78\ \tfrac{\text{m}}{\text{s}}}$$

24. (2 pts.) What is the puck's **velocity** (to the right) after the impact?

A. 1.1 m/s
B. 1.5 m/s
C. 1.9 m/s
D. 2.3 m/s
[✓ E. 2.8 m/s]

25. (2 pts.) If the paddle and puck are in contact for 2.0 ms, what is the average **force** that acts on the puck?

A. 7.5 N
[✓ B. 75 N]
C. 750 N
D. 7500 N
E. 75,000 N

$$F_{av} = \frac{\Delta p}{\Delta t} = \frac{0.15\ \text{kg}\cdot\text{m/s}}{0.0020\ \text{s}} = \underline{75\ \text{N}}$$

26. (1 pt.) While the paddle strikes the puck, the *paddle* experiences a **force** that is…

A. weaker than the force felt by the puck
[✓ B. equal in strength to the force felt by the puck] ← $\underline{\text{Newton's 3rd Law}}$: pair of forces are equal (magnitude) and opposite (direction)
C. stronger than the force felt by the puck
D. zero
E. cannot determine from the information given

An ice skater starts spinning (frictionlessly) at an angular speed of ω_0. As she pulls her arms and legs tightly against her body, her angular speed gradually increases to $3\omega_0$.

27. (2 pts.) The skater's *final* **period** of rotation was equal to ____________ times her *initial* period.

A. $\frac{1}{9}$
[✓ B. $\frac{1}{3}$]
C. 1
D. 3
E. 9

$$T = \frac{2\pi}{\omega}, \text{ so: } \frac{T_f}{T_i} = \frac{\frac{2\pi}{3\omega_0}}{\frac{2\pi}{\omega_0}} = \underline{\frac{1}{3}}.$$

28. (2 pts.) The skater's *final* **moment of inertia** was equal to ____________ times her *initial* moment of inertia.

A. $\frac{1}{9}$
[✓ B. $\frac{1}{3}$]
C. 1
D. 3
E. 9

Cons. of Angular Momentum:

$$L_f = L_i$$

$$I_f \omega_f = I_i \cdot \omega_i$$

$$\Rightarrow \frac{I_f}{I_i} = \frac{\omega_i}{\omega_f} = \frac{\omega_0}{3\omega_0} = \underline{\frac{1}{3}}$$

29. (2 pts.) Which one of the following statements is **TRUE** about the skater?

A. Both her angular momentum and her rotational kinetic energy increased.
B. Her angular momentum increased, but her rotational kinetic energy remained constant.
[✓ C. Her angular momentum remained constant, but her rotational $\underline{\text{kinetic energy increased}}$.] ↗ $K_{rot} = \frac{1}{2} I \omega^2$
D. Both her angular momentum and her rotational kinetic energy remained constant.

$$\Rightarrow \frac{K_f}{K_i} = \underline{3} \text{ times larger.}$$

30. (2 pts.) If the skater's angular speed increased uniformly from 6.0 rad/s to 18.0 rad/s over a span of 7.0 s, what was her **angular acceleration**?

A. 0.32 rad/s^2
B. 0.85 rad/s^2
C. 1.2 rad/s^2
[✓ D. 1.7 rad/s^2]
E. 2.1 rad/s^2

$$\alpha_{av} = \frac{\Delta\omega}{\Delta t} = \frac{\omega_f - \omega_i}{\Delta t} = \frac{18.0\,\frac{\text{rad}}{\text{s}} - 6.0\,\frac{\text{rad}}{\text{s}}}{7.0\,\text{s}} = \underline{1.71\ \frac{\text{rad}}{\text{s}^2}}$$

31. (2 pts.) During this 7.0 s of acceleration, how many **revolutions** did the skater make?

A. 8.3 rev
[✓ B. 13 rev]
C. 18 rev
D. 31 rev
E. 38 rev

$$\omega_f^2 = \omega_0^2 + 2\cdot\alpha\cdot\Delta\theta$$

$$(18.0\,\tfrac{\text{rad}}{\text{s}})^2 = (6.0\,\tfrac{\text{rad}}{\text{s}})^2 + 2\cdot(1.71\,\tfrac{\text{rad}}{\text{s}^2})\cdot\Delta\theta$$

$$\Rightarrow \Delta\theta = 84.0\ \text{rad} \cdot \left(\frac{1\ \text{rev}}{2\pi\ \text{rad}}\right) = \underline{13.4\ \text{rev.}}$$

Returning to the circus…

32. (2 pts.) Suppose that 14 clowns, each averaging 75 kg, all squeeze into a circus car whose interior volume is 5500 L. What is the average **density** of the packed clowns?

[✓ A.] 190 kg/m^3
B. 310 kg/m^3
C. 480 kg/m^3
D. 610 kg/m^3
E. 740 kg/m^3

$$\rho = \frac{m}{V} = \frac{14\cdot(75\,\text{kg})}{5500\,\text{L}\left(\frac{1\,\text{m}^3}{1000\,\text{L}}\right)} = \underline{\underline{191\ \frac{\text{kg}}{\text{m}^3}}}$$

33. (1 pt.) Would a chunk of pure "packed clowns" (from the previous question) **float** in water? ($\rho_{\text{water}} = 1$ g/cm^3)

[✓ A] yes
B. no

floating condition: $\rho_{\text{clowns}} \overset{?}{<} \rho_{\text{water}}$

$0.191\ \text{g}/\text{cm}^3 < 1\ \text{g}/\text{cm}^3$, so yes.

34. (3 pts.) During a particular balancing act, all eight of the Amazing Octuplets climb atop a single chair, and the chair stands on a single leg on the ground. If *each* of the eight acrobats has a mass of 50. kg, and the bottom of the chair leg has an area of 4.0 cm^2, then what is the **pressure** beneath the leg of the chair? (Ignore the chair's mass.)

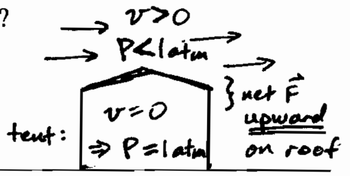
A. 38 atm
B. 52 atm
C. 77 atm
[✓ D] 97 atm
E. 140 atm

$$P = \frac{F}{A} = \frac{m\cdot g}{A} = \frac{(8\cdot 50\,\text{kg})(9.80\,\text{m}/\text{s}^2)}{(4.0\,\text{cm}^2)\left(\frac{1\,\text{m}}{100\,\text{cm}}\right)^2}$$

$$P = 9.8\times10^6\ \text{Pa}\cdot\left(\frac{1\ \text{atm}}{1.013\times10^5\ \text{Pa}}\right) = \underline{\underline{96.7\ \text{atm.}}}$$

35. (1 pt.) During this spectacle under the Big Top tent, a moderate steady breeze begins to blow outside the tent, but the air inside the tent remains still. How would you expect the **soft roof of the tent** to behave?

[✓ A] the roof will bulge upward/outward
B. there will be no change (other than a little random motion of the tent material)
C. the roof will bulge downward/inward



36. (2 pts.) While watching the spectacle, you drink 750 g of chilled water at 10°C. How much **heat** must your body give to the water to warm it up to 37°C (body temperature)? *Note:* $c_{\text{water}} = 1000$ cal/(kg·K) = 4186 J/(kg·K)

A. 1.2 kcal
B. 3.0 kcal
C. 7.5 kcal
D. 13 kcal
[✓ E] 20. kcal

$Q = m\cdot c_w\,\Delta T$

$\Delta T = 37°\text{C} - 10°\text{C} = 27°\text{C} = \underline{27\,\text{K}}.$

$= (0.750\,\cancel{\text{kg}})\left(1000\,\frac{\text{cal}}{\cancel{\text{kg}}\cdot\cancel{\text{K}}}\right)(27\,\cancel{\text{K}})$

$= \underline{20{,}250\ \text{cal}}$

37. (1 pt.) Next to you, your little cousin is slurping down some shave-ice: assume that he eats 750 g of solid ice at a temperature of –5.0°C. His body will also warm it all the way up to liquid water at 37°C. In addition to the heat you calculated in the previous question, your cousin's body will *also* need to add all of the following amounts of heat **EXCEPT:**

A. heat of fusion = melting (transition from solid → liquid) – yes.
[✓ B] heat of vaporization = boiling (liquid → vapor) – no.
C. increasing temperature of solid ice from –5°C to 0°C – yes.
D. increasing temperature of liquid water from 0°C to 10°C – yes.

38. (1 pt.) As the ice melts, its **entropy**…

[✓ A] increases
B. remains unchanged
C. decreases

$\Delta S = \frac{Q}{T_{av}}$. As ice melts, it absorbs $Q = m\cdot L_f$ (heat of fusion) while $T = 273\,\text{K}$ (constant), so $\underline{\Delta S \text{ is positive}}$ ⇒ $\underline{\text{entropy increases}}$.

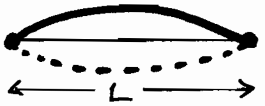
wire **A**:

wire **B**:

Two high-wire acrobats are walking along different high wires: both wire *A* and wire *B* have the *same* length *L* and *same* tension force, but wire *A* is made of a relatively thin, lightweight cable, while wire *B* is thicker and heavier. Both have fixed ends. As the acrobats shuffle their feet along the wires, the wires begin to vibrate up and down, exciting standing-wave modes along the wires. (Ignore any effect of the acrobats' own weight or position.)

39. (2 pts.) If $L = 15$ m, what is the **wavelength** of the *fundamental* standing-wave mode in both wires?

A. 3.8 m
B. 7.5 m
C. 15 m
[✓ D. 30. m]
E. 60. m



By inspection,
$\lambda_1 = 2L = 2\cdot(15\,m) = \underline{\underline{30.m}}$

40. (2 pts.) Which one of the following is **TRUE** about the fundamentals of the two wires? *Recall:* $v = \sqrt{\frac{F_T}{(m/L)}}$ $\to \mu$.

[✓ A. Wire *A* has a higher-frequency fundamental than wire *B*.]
B. Wire *B* has a higher-frequency fundamental than wire *A*.
C. Both wires have the same fundamental frequency.

$\lambda_1 f_1 = v$, so: $f_1 = \frac{v}{\lambda_1}$

Wire B has larger μ than wire A. (L and F_T are same for both.) $\underline{\underline{f_1 = \frac{1}{2L}\cdot\sqrt{\frac{F_T}{\mu}}}}$.

41. (1 pt.) The standing-wave patterns that oscillate along these wires are…

A. **longitudinal** waves
[✓ B. **transverse** waves] – displacement of wire is perpendicular to v of waves.

The following two questions pertain *only* to Wire *A:*

42. (2 pts.) If you observe the wire's fundamental to have a frequency of 2.0 Hz, what is the **speed** of the waves along the wire?

A. 3.8 m/s
B. 7.5 m/s
C. 15 m/s
D. 30. m/s
[✓ E. 60. m/s]

from question #39.
$\lambda_1 \cdot f_1 = v \Rightarrow v = (30.\,m)(2.0\,Hz)$
$= \underline{\underline{60.\,m/s}}$

43. (2 pts.) Which one of the following *is* a **frequency** of one of the wire's *overtones*?

A. 1.0 Hz
B. 2.5 Hz
C. 5.0 Hz
[✓ D. 10. Hz]
E. 15 Hz

Frequency of n^{th} overtone: $f_n = n \cdot f_1 = \{\underline{2.0\,Hz,\ 4.0\,Hz,\ 6.0\,Hz,\ 8.0\,Hz,\ 10.0\,Hz, \ldots}\}$

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44. (2 pts.) While watching a 52-kg trapeze artist high overhead, you see that she swings back and forth at the end of a long swing, completing one cycle every 5.3 s. (Ignore air resistance. Assume that she can be approximated as an ideal pendulum.) How **long** are ~~is~~ her swing's cables?

A. 5.0 m
B. 5.5 m
C. 6.0 m
D. 6.5 m
[✓ E. 7.0 m]

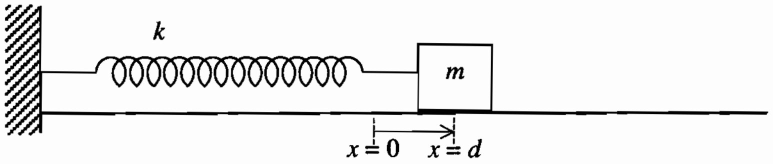
$T = 2\pi\sqrt{\frac{L}{g}} \Rightarrow L = g\cdot\left(\frac{T}{2\pi}\right)^2 = \left(9.80\,\frac{m}{s^2}\right)\left(\frac{5.3\,s}{2\pi}\right)^2$
$= \underline{\underline{6.97\,m}}$

45. (1 pt.) While in mid-swing, she catches an equal-mass team member, and the two of them form a tight ball ($m =$ 104 kg) at the end of the swing. How does this affect the **period** of her swings?

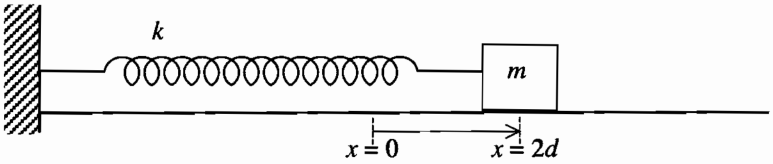
A. new period is longer
[✓ B. period is unchanged]
C. new period is shorter

$\underline{\underline{T = 2\pi\sqrt{\frac{L}{g}}}} \Rightarrow$ does NOT depend on mass m of pendulum bob!

System **A**:



System **B**:



Identical masses *m* are attached to identical ideal, massless springs *k*, as shown above. The surface is frictionless. The mass in system *A* is initially pulled aside to a displacement of *x* = *d*, while the mass in system *B* is initially displaced twice as far. Both masses are then released from rest and allowed to oscillate freely.

46. (2 pts.) System *A* has a **period** equal to __________ times that of system *B*.

A. $\frac{1}{2}$
B. $\frac{1}{\sqrt{2}}$
[✓ C.] 1
D. $\sqrt{2}$
E. 2

$\omega_0 = \sqrt{\frac{k}{m}}$ and $\omega_0 = \frac{2\pi}{T_0}$

$\Rightarrow \underline{\underline{T_0 = 2\pi\sqrt{\frac{m}{k}}}}$ ← does NOT depend on amplitude of oscillations!

47. (2 pts.) System *A* has a **total energy** equal to __________ times that of system *B*.

A. $\frac{1}{8}$
[✓ B.] $\frac{1}{4}$
C. $\frac{1}{2}$
D. $\frac{1}{\sqrt{2}}$
E. 1

$E_{tot} = K + U_{el}$, at $x = A$ and $v = 0$:

$\Rightarrow E_{tot} = \frac{1}{2}m\overset{0}{\cancel{v}^2} + \frac{1}{2}kx^2 = \underline{\underline{\frac{1}{2}kA^2}}$.

48. (2 pts.) System *A*'s mass has a **maximum speed** equal to __________ times that of system *B*.

[✓ A.] $\frac{1}{2}$
B. $\frac{1}{\sqrt{2}}$
C. 1
D. $\sqrt{2}$
E. 2

$E_{x=0} = E_{x=A}$ (where $E = K + U_{el}$)

$\frac{1}{2}mv_{max}^2 + \frac{1}{2}\overset{0}{\cancel{kx^2}} = \frac{1}{2}m\overset{0}{\cancel{v^2}} + \frac{1}{2}kx_A^2$

$\Rightarrow \underline{\underline{v_{max} = \sqrt{\frac{k}{m}}\cdot A}}$

Suppose that *k* = 25 N/m, *m* = 750 g, and *d* = 12 cm in the two systems described above.

49. (2 pts.) At what **displacement** ***x*** does the mass in System *A* experience a horizontal force of 1.8 N?

A. ±2.4 cm
B. ±4.8 cm
C. ±6.0 cm
[✓ D.] ±7.2 cm
E. ±9.0 cm

$F_{spr} = -k\cdot x$

$\pm 1.8N = -(25\frac{N}{m})\cdot x$

$\Rightarrow x = \underline{\underline{\pm 0.072 m}}$

50. (2 pts.) At what **frequency** should you apply a driving force to the mass in System *B* to cause *resonance* to occur?

[✓ A.] 0.92 Hz
B. 1.4 Hz
C. 2.1 Hz
D. 2.6 Hz
E. 3.3 Hz

Resonance occurs when $\omega_{driving} = \omega_0$

$\Rightarrow f_d = f_0 = \frac{1}{2\pi}\sqrt{\frac{k}{m}} = \frac{1}{2\pi}\sqrt{\frac{25\frac{N}{m}}{0.750 kg}} = \underline{\underline{0.92 Hz}}$

51. (1 pt.) If System *B* is driven at this resonant frequency by a small-amplitude driving force, then…

A. the system's period of oscillation will grow longer and longer
B. the system's period of oscillation will shrink to zero
[✓ C.] the system's amplitude of oscillation will grow larger and larger
D. the system's amplitude of oscillation will shrink to zero

(A, B) no, T will remain: $T_d = \frac{1}{f_{driving}}$.

(C) ← yes, this describes <u>resonance</u>.

MATCHING… use each of the boxed terms *NO MORE THAN ONCE (or not at all)*:

D **52.** (1 pt.) A thermodynamic process that maintains constant temperature.

A **53.** (1 pt.) A thermodynamic process that has zero heat flow.

B **54.** (1 pt.) A thermodynamic process that maintains constant pressure.

A. adiabatic ⇒ $Q = 0$

B. isobaric ⇒ constant P

C. isochoric ⇒ constant V

D. isothermal ⇒ constant T

A. Newton's 1st Law of Motion
B. Newton's 2nd Law of Motion
C. Newton's 3rd Law of Motion
D. Newton's Law of Gravitation
E. Kepler's 3rd Law

C **55.** (1 pt.) "Law of Action & Reaction"

A **56.** (1 pt.) "Law of Inertia"

E **57.** (1 pt.) Law that describes orbital motion of planets or satellites

D **58.** (1 pt.) All masses attract all other masses in the universe.

C **59.** (1 pt.) When a wave source and an observer approach each other, the observer will detect an increase in the frequency of the waves.

D **60.** (1 pt.) Equal pressure is transmitted instantly to all walls of a closed container or system.

A **61.** (1 pt.) A floating object displaces an amount of fluid whose weight equals the weight of the floating object.

E **62.** (1 pt.) Two waves' displacements add when both waves pass through the same medium, resulting in constructive or destructive interference.

A. Archimedes' Principle

B. Bernoulli Effect

C. Doppler Effect

D. Pascal's Principle

E. Principle of Superposition

63. (1 pt.) Three Great **Conservation Laws** we learned this semester are: Conservation Of…
A. Gravitation, Electromagnetism, and Nuclear forces
B. Work, Heat, and Energy
C. Force, Momentum, and Torque
D. Elastic Potential Energy, Gravitational Potential Energy, and Kinetic Energy
[✓ E.] Energy, Momentum, and Angular Momentum