PHYSICS 114 PRACTICE FINAL EXAM
VERSION A - SOLUTION

Last Name (Print): ______________________ First Name (Print): _____________________

Honor Pledge: *All work presented here is my own.*

Signature: ______________________________ Student ID: _________________________

READ THIS ENTIRE PAGE NOW
Do not open the exam until told to do so.
You will have 110 minutes to complete the examination.

NO CELL PHONES, TEXT MSG, etc. ALLOWED AT ANY TIME.

Before the exam begins:

- Print and sign your name, and write your student ID number in the spaces above.

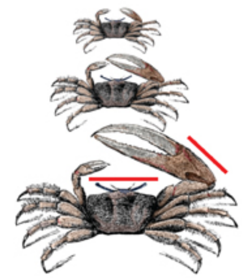
During the exam

- If you are confused about a question, raise your hand and ask for an explanation.
- If you cannot do one part of a problem, move on to the next part.
- This is a closed book examination. All equations and constants are provided.
- You may use a calculator, but not a computer, or other internet connected devices (smart-phones, iPads, etc.).
- Clearly circle your answer choice. Make no stray marks. If you must erase, erase completely.

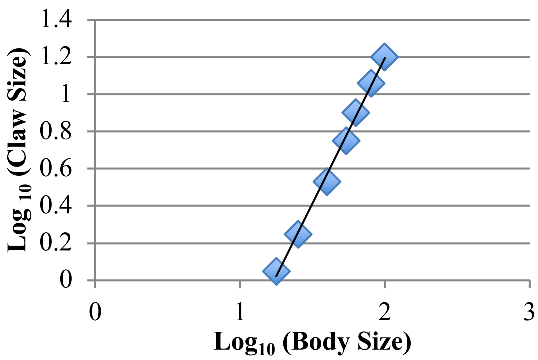
End of exam:

- Out of respect to other students, please remain seated for the last 20 minutes of the exam. At the end of the exam, please remain seated until all exams have been collected.

1. [6 pts] The graph and table below show how the claw size (c) varies with body size (b) in a growing male fiddler crab. Which of the equations below best represents the relationship between these two quantities?



A) $c = 0.01b^{1.5}$	B) $c = 0.2b^{1.3}$	C) $c = 2b^{2.1}$
D) $c = 0.1b^{1.5}$	E) $c = 0.3b^{1.9}$	



Body Size (mm)	Claw Size (mm)
17.8	1.1
25.1	1.8
39.8	3.4
54.0	5.6
63.1	8.0
80.0	11.5
100.0	15.8

The trendline of the graph above has an equation: $log_{10}(claw\ size) = mlog_{10}(body\ size) + c$. *We can determine the value of the slope as follows:*

$$slope = m = \frac{log_{10}(15.8) - log_{10}(1.1)}{log_{10}(100) - log_{10}(17.8)} = 1.54$$

Since the slope is equal to the value of the exponent in the power law function, we can rule out choices B, C and E. The intercept can be determined as follows. Note that the "c" below refers to the y-intercept and not the claw size.

$$log_{10}(claw\ size) = mlog_{10}(body\ size) + c$$

$$c = log_{10}(claw\ size) - mlog_{10}(body\ size)$$

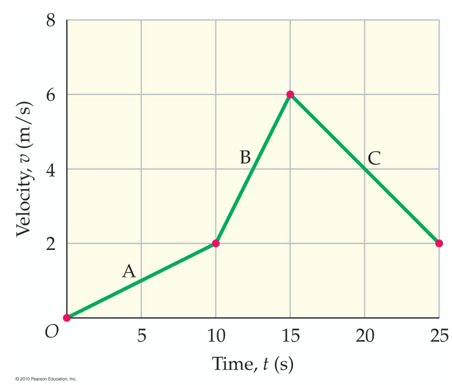
$$c = log_{10}(15.8) - (1.54)log_{10}(100) = -1.89$$

The relationship can now be determined:

$$c = 10^{-1.89}b^{1.54}$$

$$c = 0.01b^{1.5}$$

2. [6 pts] A cyclist moves according to the velocity-versus-time graph shown at right. If the cyclist is at a position of $x = 10$ m at $t = 0$ s, at what time is the cyclist at $x = 65$ m?



A) 5 s

B) 10 s

C) 15 s

D) 20 s

E) 25 s

The area under a velocity versus time curve is equal to displacement. The cyclist's displacement is 55 m (65 m – 10 m).

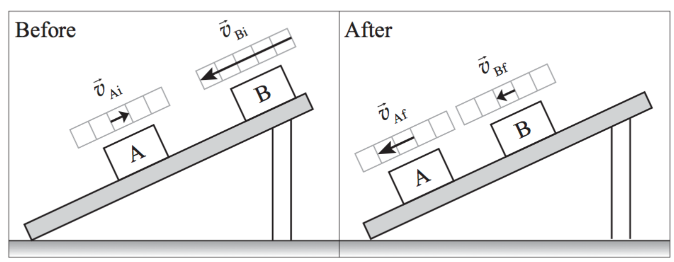
$$\Delta x_{0\ to\ 10s} = \frac{1}{2}(10\text{ s})(2\text{ m/s}) = 10\text{ m}$$

$$\Delta x_{10\ to\ 15s} = (5\text{ s})(2\text{ m/s}) + \frac{1}{2}(5\text{ s})(4\text{ m/s}) = 20\text{ m}$$

$$\Delta x_{15\ to\ 20s} = (5\text{ s})(4\text{ m/s}) + \frac{1}{2}(5\text{ s})(2\text{ m/s}) = 25\text{ m}$$

From above, we can see that it takes 20 s for the cyclist to travel 55 m.

Two blocks, A and B, collide on a frictionless ramp. The instantaneous velocity vectors of the two blocks are shown on the diagrams at right for instants before and after the collision.



3. [6 pts] If the initial velocity of block A is 1 m/s, what is the change in velocity for block A and for block B? Assume up the ramp is the positive direction.

A) Block A: -1 m/s	Block B: 6 m/s
B) Block A: -1 m/s	Block B: 4 m/s
C) Block A: -3 m/s	Block B: -6 m/s
D) Block A: -3 m/s	Block B: 4 m/s
E) Block A: 3 m/s	Block B: 6 m/s

Block A has an initial velocity of 1 m/s and block B has an initial velocity -5 m/s. The final velocity of block A is -2 m/s and block B is -1 m/s. The change in velocities of block A and B are thus:

$$\Delta v_A = v_{f,A} - v_{i,A} = -2\text{ m/s} - (1\text{ m/s}) = -3\text{ m/s}$$
$$\Delta v_B = v_{f,B} - v_{i,B} = -1\text{ m/s} - (-5\text{ m/s}) = 4\text{ m/s}$$

4. [6 pts] Romeo is chucking pebbles gently up to Juliet's window, and he wants the pebbles to hit the window with only a horizontal component of velocity. He is standing at the edge of a rose garden 8.0 m below her window and 9.0 m from the base of the wall. How fast are the pebbles going when they hit her window?

A) 4.6 m/s	B) 5.2 m/s	C) 5.9 m/s	D) 6.4 m/s	E) 7.0 m/s

First solve for the initial y-velocity knowing that at the top of the flight the y-velocity is zero since the pebbles are traveling horizontally.

$$v_{f,y}^2 = v_{f,i}^2 - 2g\Delta y = 0$$

$$v_{i,y} = \sqrt{2g\Delta y} = \sqrt{2(9.8\ \text{m/s}^2)(8.0\ \text{m})} = 12.5\ \text{m/s}$$

Now solve for the time the pebbles are in the air.

$$\Delta t = \frac{v_{i,y}}{g} = \frac{12.5\ \text{m/s}}{9.8\ \text{m/s}^2} = 1.28\ \text{s}$$

Finally solve for the x-velocity which is constant for the pebbles.

$$v_x = \frac{\Delta x}{\Delta t} = \frac{9.0\ \text{m}}{1.28\ \text{s}} = 7.0\ \text{m/s}$$

5. [6 pts] A soccer ball is kicked with an initial speed of 10.2 m/s in a direction 25.0° above the horizontal. Find the direction of the ball's velocity 0.500 s after being kicked.

A) 5.10° above the horizontal

B) 2.45° above the horizontal

C) 3.65° below the horizontal

D) 10.6° below the horizontal

E) 16.5° below the horizontal

The x-velocity is constant for a projectile and is determined below.

$$v_x = v cos\theta = (10.2\ \text{m/s})cos(25.0°) = 9.24\ \text{m/s}$$

The y-velocity changes at a constant rate, g.

$$v_{f,y} = v_{i,y} - gt = v sin\theta - gt = (10.2\ \text{m/s})sin(25.0°) - (9.8\ \text{m/s}^2)(0.500\ \text{s}) = -0.59\ \text{m/s}$$

$$\theta = tan^{-1}\left(\frac{0.59\ \text{m/s}}{9.24\ \text{m/s}}\right) = 3.65°$$

6. [6 pts] What average net force is required to stop an 1100-kg car in 8.0 s if it is traveling at 90 km/hr?

A) 2.9 kN	B) 3.4 kN	C) 4.1 kN	D) 5.9 kN	E) 6.3 kN

$$F_{avg} = ma_{avg} = m\frac{\Delta v}{\Delta t} = (1100\text{ kg})\frac{\frac{90(1000\text{ m})}{3600\text{ s}}}{8.0\text{ s}} = 3440\text{ N} = 3.4\text{ kN}$$

7. [6 pts] As part of a physics experiment, you stand on a bathroom scale in an elevator. Though your normal weight is 610 N, the scale at the moment reads 730 N. Calculate the magnitude of the elevator's acceleration?

A) 1.05 m/s²	B) 9.81 m/s²	C) 2.87 m/s²	D) 1.93 m/s²	E) 2.18 m/s²

$$N - W = ma$$

$$a = \frac{N - W}{m} = \frac{730\text{ N} - 610\text{ N}}{610\text{ N}/9.8\text{ m/s}^2} = 1.93\text{ m/s}^2$$

8. [6 pts] A person pushes a 14.5-kg lawnmower at a constant acceleration of 0.600 m/s^2. The person applies an 88.0 N force directed down along the handle, which is at an angle of 45.0° to the horizontal. What is the magnitude of the friction force on the lawnmower?

A) 53.5 N

B) 55.6 N

C) 59.2 N

D) 60.8 N

E) 63.7 N

$$F_{net} = ma$$

$$F_{handle,x} - f = ma$$

$$f = F_{handle,x} - ma = (88\text{ N})(cos(45°)) - (14.5\text{ kg})(0.600\text{ m/s}^2) = 53.5\text{ N}$$

9. [7 pts] In downhill speed skiing a skier is retarded by both the air drag force on the body and the kinetic frictional force on the skis. Suppose the slope is $\theta = 40.0°$, the snow is dry snow with a coefficient of kinetic friction $\mu_k = 0.0400$, the mass of the skier and equipment is $m = 85.0$ kg, the cross-sectional area of the skier is $A = 1.30$ m^2, the drag coefficient is C = 0.170, and the air density is 1.20 kg/m^3. What is the terminal speed of the skier?

A) 38.2 m/s	B) 47.8 m/s	C) 55.9 m/s	D) 62.0 m/s	E) 68.1 m/s

$$F_{net} = ma$$

$$W - f - D = ma = 0$$

$$D = \frac{1}{2}C_D\rho A v_T^2 = W - f = mgsin\theta - \mu_k mgcos\theta$$

$$v_T = \sqrt{\frac{2mg(sin\theta - \mu_k mgcos\theta)}{C_D\rho A}} = 62\ \text{m/s}$$

10. [6 pts] A 0.40-kg ball, attached to the end of a horizontal cord, is rotated in a circle of radius 1.3 m on a frictionless horizontal surface. If the cord will break when the tension in it exceeds 60.0 N, what is the maximum linear speed the ball can have?

A) 11 m/s	B) 14 m/s	C) 16 m/s	D) 19 m/s	E) 23 m/s

$$T = ma = m\frac{v^2}{r}$$

$$v = \sqrt{\frac{Tr}{m}} = \sqrt{\frac{(60.0\ \text{N})(1.3\ \text{m})}{0.40\ \text{kg}}} = 14\ \text{m/s}$$

11. [7 pts] A 40-cm-diameter wheel accelerates uniformly from 240 rpm to 360 rpm in 6.5 s. How far will a point on the edge of the wheel have traveled in this time?

A) 35 m	B) 38 m	C) 41 m	D) 48 m	E) 59 m

$$\Delta x = 2\pi r\Delta\theta_{rev} = 2\pi r(\omega_{avg}\Delta t)$$

$$\omega_{avg} = \frac{360\ \text{rpm} + 240\ \text{rpm}}{2} = 300\ \text{rpm} = 5\ \text{rps}$$

$$\Delta x = 2\pi(0.20\ \text{m})(5\ \text{rps})(6.5\ \text{s}) = 41\ \text{m}$$

12. [6 pts] You are holding a shopping basket at the grocery store with two 0.56-kg cartons of cereal at the left end of the basket. The basket is 0.71 m long. Where should you place a 1.8-kg half gallon of milk, relative to the left end of the basket, so that the center of mass of your groceries is at the center of the basket?

A) 0.58 m	B) 0.65 m	C) 0.19 m	D) 0.27 m	E) 0.35 m

$$m_{c1}x_{c1} + m_{c2}x_{c2} = m_m x_m$$

$$x_m = \frac{m_{c1}x_{c1} + m_{c2}x_{c2}}{m_m} = \frac{(0.56\text{ kg})(0.355\text{ m}) + (0.56\text{ kg})(0.355\text{ m})}{1.8\text{ kg}} = 0.22\text{ m}$$

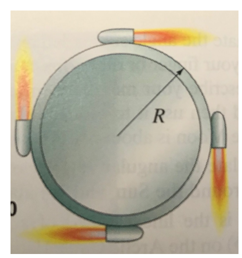
From the left end: $x_m = 0.355\text{ m} + 0.22\text{ m} = 0.58\text{ m}$

13. [6 pts] A softball player swings a bat, accelerating it from rest to 18.8 rad/s in a time of 0.200 s. Approximate the bat as a 2.2-kg uniform rod of length 0.950-m rotating about one of its ends, and compute the torque the player applies to one end of it. $I_{rod} = \frac{1}{3}mL^2$ (Assume the player applies the net torque to the bat.)

A) 53.1 Nm	B) 62.2 Nm	C) 78.1 Nm	D) 89.3 Nm	E) 97.3 Nm

$$\tau_{net} = I\alpha = \frac{1}{3}(2.2\text{ kg})(0.95\text{ m})^2\left(\frac{18.8\text{ rad/s}}{0.200\text{ s}}\right) = 62.2\text{ Nm}$$

14. [7 pts] In order to get a flat uniform cylindrical satellite spinning at constant rate, engineers fit four tangential rockets as shown. If the satellite has a mass of 2600 kg and a radius of 3.0 m, what is the required steady force of each rocket if the satellite is to reach 30 rpm in 5.0 min? $I_{solid\ disk} = \frac{1}{2}mR^2$

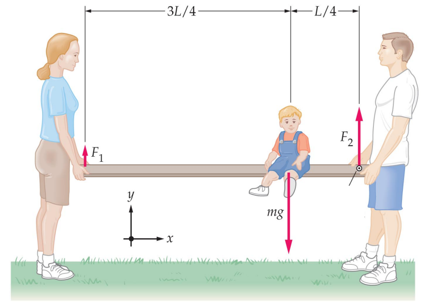


A) 7.2 N	B) 8.1 N	C) 9.4 N	D) 10 N	E) 13 N

$$\tau_{net} = 4FR = I\alpha$$

$$F = \frac{I\alpha}{4R} = \frac{mR^2\alpha}{8R} = \frac{mR\alpha}{8} = \frac{(2600\text{ kg})(3.0\text{ m})\left(\frac{3.14\text{ rad/}s}{300\text{ s}}\right)}{8} = 10.2\text{ N}$$

15. [6 pts] A child of mass m is supported on a plank by his parents, who exert forces F_1 and F_2 as indicated. The plank also has a mass m, and is in static equilibrium. Find the value of F_1 in terms of m and g. Briefly show your work.



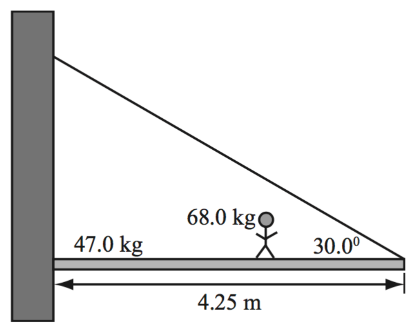
A) $\frac{1}{4}mg$ B) $\frac{1}{3}mg$ C) $\frac{2}{5}mg$

D) $\frac{3}{5}mg$ E) $\frac{3}{4}mg$

$$mg\frac{L}{4} + mg\frac{L}{2} = F_1 L$$

$$F_1 = \frac{3}{4}mg$$

16. [7 pts] A 47.0-kg uniform rod 4.25 m long is attached to a wall with a hinge at one end. The rod is held in a horizontal position by a wire attached to its other end. The wire makes an angle of 30.0° with the horizontal, and is bolted to the wall directly above the hinge. If the wire can withstand a maximum tension of 1450 N before breaking, how far from the wall can a 68.0-kg person sit without breaking the wire



A) 3.47 m

B) 2.85 m

C) 3.15 m

D) 3.23 m

E) 3.92 m

$$\tau_{net} = -\tau_{person} - \tau_{weight} + \tau_{tension} = 0$$

$$\tau_{person} = \tau_{tension} - \tau_{weight}$$

$$m_{person} g r_{person} = T\sin(30°) r_T - m_{rod} g r_{rod}$$

$$r_{person} = \frac{T\sin(30°) r_T - m_{rod} g r_{rod}}{m_{person} g} = \frac{(1450\text{ N})\sin(30°)(4.25\text{ m}) - (47.0\text{ kg})(9.8\text{ m/s}^2)(2.125\text{ m})}{(68.0\text{ kg})(9.8\text{ m/s}^2)}$$

$$r_{person} = 3.15\text{ m}$$

17. [6 pts] An small jeep is parked on a steep banked curve that is 32.0° above the horizontal. What is the maximum center of gravity height the jeep can have such that it will not topple over? The jeep has a width of 1.90 meters.

A) 1.27 m	B) 1.35 m	C) 1.52 m	D) 1.74 m	E) 1.86 m

$$\theta_c = tan^{-1}\left(\frac{0.5\ t}{h}\right)$$

$$tan\theta_c = \left(\frac{0.5\ t}{h}\right)$$

$$h = \left(\frac{0.5\ t}{tan\theta_c}\right) = \left(\frac{0.5(1.90\ \text{m})}{tan(32.0°)}\right) = 1.52\ \text{m}$$

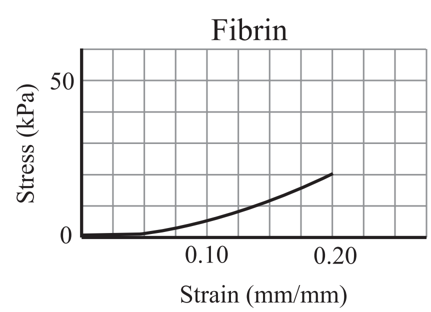
18. [6 pts] A 3.50 kg block is held on a compressed vertical spring that has a spring constant of 800 N/m. The spring is initially compressed a distance of 8.00 cm from its equilibrium position. Determine the acceleration of the block at the moment the block is released.

A) 8.48 m/s^2	B) 9.17 m/s^2	C) 9.81 m/s^2	D) 14.9 m/s^2	E) 18.3 m/s^2

$$F_{net} = F_{sp} - W = ma$$

$$a = \frac{F_{sp} - W}{m} = \frac{k\Delta l - mg}{m} = \frac{(800\ \text{N/m})(0.08\ \text{m}) - (3.50\ \text{kg})(9.8\ \text{m/s}^2)}{3.50\ \text{kg}} = 8.48\ \text{m/s}^2$$

19. [6 pts] The graph at right shows the result of an experiment conducted in 2004 by scientists at Georgia Tech, in which they stretched a sample of fibrin until it broke (the point at where the curve ends). If the sample was originally 38 mm long before the stress was aplied, what was the final length of the sample?



A) 8 mm

B) 46 mm

C) 0.2 mm

D) 38.2 mm

E) 80 mm

$$Strain = \frac{\Delta l}{l}$$

$$\Delta l = Strain(l) = 0.2(38\ \text{mm}) = 7.6\ \text{mm} \qquad l_{final} = l + \Delta l = 45.6\ \text{mm}$$

20. [6 pts] A 0.285-kg ball falls vertically downward, hitting the floor with a speed of 2.50 m/s and rebounding upward with a speed of 2.0 m/s. Determine the magnitude of the impulse delivered to the ball by the floor?

A) 1.46 kgm/s	B) 0.854 kgm/s	C) 1.28 kgm/s	D) 0.143 kgm/s	E) 1.15 kgm/s

$$J = \Delta p = m(v_f - v_i)$$

$$J = (0.285\text{ kg})(2.0\text{ m/s} - (-2.50\text{ m/s})) = 1.28\text{ m/s}$$

21. [6 pts] Force A has a magnitude F and acts for a time Δt, force B has a magnitude $2F$ and acts for a time $\Delta t/3$, and force C has a magnitude $5F$ and acts for a time $\Delta t/10$. Rank these forces in terms of impulse delivered by each force.

A) C > B > A

B) A> B > C

C) B > A > C

D) A = B > C

E) A = C > B

$$J_A = F\Delta t$$

$$J_B = 2F\frac{\Delta t}{3} = \frac{2}{3}F\Delta t$$

$$J_C = 5F\frac{\Delta t}{10} = \frac{1}{2}F\Delta t$$

22. [7 pts] A bullet with a mass of 4.00 g and a speed of 550.0 m/s is fired at a block of wood with a mass of 3.20 kg. The block rests on a frictionless surface, and the bullet becomes embedded in the block. What is the final speed of the block?

A) 0.549 m/s	B) 0.592 m/s	C) 0.687 m/s	D) 0.749 m/s	E) 0.828 m/s

$$p_{bu,i} + p_{bl,i} = p_{bu,f} + p_{bl,f}$$

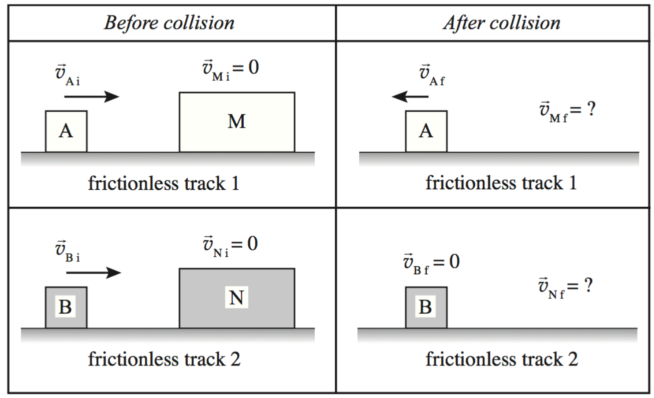
$$m_{bu}v_{bu,i} + m_{bl}v_{bl,i} = (m_{bu} + m_{bl})v_{bu\_bl,f}$$

$$v_{bu\_bl,f} = \frac{m_{bu}v_{bu,i} + m_{bl}v_{bl,i}}{(m_{bu} + m_{bl})} = \frac{(0.004\text{ kg})(550\text{ m/s}) + (3.20\text{ kg})(0\text{ m/s})}{(0.004\text{ kg} + 3.20\text{ kg})} = 0.687\text{ m/s}$$

Four blocks are arranged on two level, frictionless tracks as shown. Blocks A and B are launched with the *same initial velocity* toward the stationary blocks M and N, respectively. After the collisions, block A has reversed direction and block B is at rest

The masses of block A and B are equal, as are the masses of blocks M and N. The mass of block M is five times that of block A.

Note: Blocks A and M are made of different materials than block B and N.



$m_A = m_B$
$m_M = m_N$
$m_M = 5m_A$

23. [6 pts] After the collisions, is the speed of block M *greater than, less than,* or *equal to* the speed of block N? If the speed of either block is zero, state so explicitly

A) Greater than

B) Less than

C) Equal to

D) Not enough information to answer.

Since the tracks are frictionless and horizontal, there is no change in the momentum of the AM system or the BN system. After the collision of block A and block M, block A moves back to the left. This means that the magnitude of the final momentum of block M must be larger than the magnitude of the initial momentum of block A.

After the collision of block B and block N, block B comes to rest. This means that block N has the same momentum as the initial momentum of block B. Since blocks A and B have both the same mass and initial velocity, they have the same initial momentum.

Combining the logic above, it can concluded that the final momentum of block M is larger in magnitude than the final momentum of block N. As blocks M and N have the same mass, block M must have a larger final speed.

24. [6 pts] Consider system X, which consists of block B and block N. Is the final kinetic energy of system X *greater than, less than* or *equal to* the initial kinetic energy of system X? Explain

A) Greater than

B) Less than

C) Equal to

D) Not enough information to answer.

The initial kinetic energy of the system is the initial kinetic energy of block B since block N is at at rest. Thus: $K_i = \frac{1}{2} m_B v_B^2$. *Block N has a mass five times that of block B. Since the momentum of the system of the two blocks is constant and block B comes to rest in the collision, the final speed of block N is 1/5 of the initial speed of block B. Thus the final kinetic energy is:*

$$K_f = \frac{1}{2} 5m_B \left(\frac{v_B}{5}\right)^2 = \frac{1}{5}\left(\frac{1}{2} m_B v_B^2\right) = \frac{1}{5} K_i$$

25. [7 pts] A block of mass *m* and speed *v* collides with a spring, compressing it a distance Δ*x*. What is the compression of the spring if the force constant of the spring is increased by a factor of four?

A) 4Δ*x*

B) 0.5Δ*x*

C) 2Δ*x*

D) 0.25Δ*x*

E) 0.0625Δ*x*

$$K_i = U_{sf}$$

$$\frac{1}{2} m v^2 = \frac{1}{2} k (\Delta x)^2$$

$$\Delta x = \sqrt{\frac{m v^2}{k}}$$

$$\Delta x' = \sqrt{\frac{m v^2}{4k}} = \sqrt{\frac{1}{4}}\sqrt{\frac{m v^2}{k}} = \frac{1}{2}\sqrt{\frac{m v^2}{k}} = \frac{1}{2}\Delta x$$

26. [6 pts] A 51-kg packing crate is pulled with constant speed across a rough floor with a rope that is at an angle of 33.5° above the horizontal. If the tension in the rope is 115 N, how much work is done on the crate by the tension force, if the crate moves 8.0 m? Show your work.

A) 510 J	B) 640 J	C) 770 J	D) 840 J	E) 920 J

$W = T\Delta x cos\theta$

$W = (115\text{ N})(8.0\text{ m})cos(33.5°) = 770\text{ J}$

27. [6 pts] A sled slides without friction down a small, ice-covered hill. If the sled starts from rest at the top of the hill, its speed at the bottom is 7.50 m/s. On a second run, the sled starts with a speed of 1.50 m/s at the top. Find the speed of the sled at the bottom of the hill after the second run.

A) 10.0 m/s	B) 9.00 m/s	C) 7.65 m/s	D) 8.75 m/s	E) 5.63 m/s

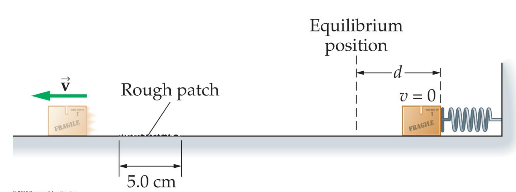
$Run\ 1{:}\ mgh = \frac{1}{2}m(7.50\text{ m/s})^2$

$Run\ 2{:}\ mgh = \frac{1}{2}m\left(v_f^2 - (1.50\text{ m/s})^2\right) = \frac{1}{2}m(7.50\text{ m/s})^2$

$v_f^2 - (1.50\text{ m/s})^2 =$

$v_f = \sqrt{(7.50\text{ m/s})^2 + (1.50\text{ m/s})^2} = 7.65\text{ m/s}$

28. [7 pts] A 1.20-kg block is held at rest against a spring with a force constant $k = 730.0$ N/m. Initially, the spring is compressed a distance 9.73 cm. When the block is released, it slides across a surface that is frictionless except for a rough patch of width 5.0 cm that has applies a friction force of magnitude 5.61 N. What is the speed of the block after it passes across the rough patch?



A) 1.45 m/s	B) 1.93 m/s	C) 2.30 m/s	D) 2.75 m/s	E) 3.16 m/s

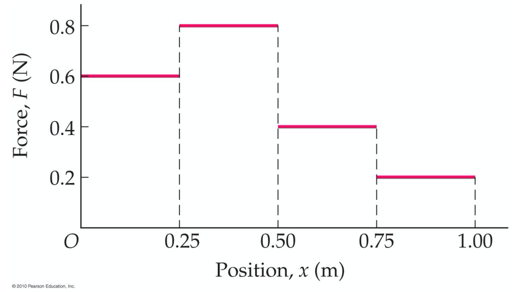
Consider a system of the block-floor and spring. There is no net work done on this system.

$K_i + U_{s,i} + E_{th,i} = K_f + U_{s,f} + E_{th,f}$

$$0 + \frac{1}{2}kd^2 + 0 = \frac{1}{2}mv_f^2 + 0 + f\Delta x$$

$$v_f = \sqrt{\frac{kd^2 - 2f\Delta x}{m}} = \sqrt{\frac{(730\text{ N/m})(0.0973\text{ m})^2 - 2(5.61\text{ N})(0.05\text{ m})}{1.20\text{ kg}}} = 2.30\text{ m/s}$$

29. [6 pts] The force shown in the figure at right acts on a 1.7-kg object whose initial speed is 0.44 m/s and initial position is $x = 0.27$ m. Find the speed of the object when it is located at $x = 0.73$ m.



A) 0.45 m/s

B) 0.51 m/s

C) 0.60 m/s

D) 0.25 m/s

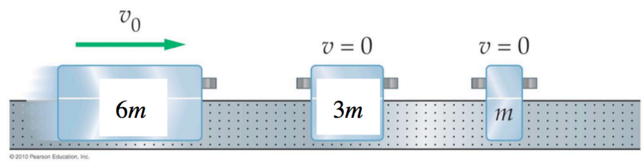
E) 0.72 m/s

$$W = (0.8\text{ N})(0.23\text{ m}) + (0.4\text{ N})(0.23\text{ m}) = 0.276\text{ J}$$

$$W = \Delta K = \frac{1}{2}m\left(v_f^2 - v_i^2\right) = 0.276\text{ J}$$

$$v_f = \sqrt{\frac{2(0.276\text{ J})}{m} + v_i^2} = 0.72\text{ m/s}$$

30. [7 pts] The three air carts shown below have masses, reading from left to right, of 6*m*, 3*m*, and *m*, respectively. The most massive cart has an initial speed of v_0; the other two carts are at rest initially. All carts are equipped with spring bumpers that give elastic collisions. Find the final kinetic energy of the *m* glider.



A) $K_f = 2mv_o^2$

B) $K_f = \frac{8}{9}mv_o^2$

C) $K_f = \frac{8}{3}mv_o^2$

D) $K_f = \frac{1}{3}mv_o^2$

E) $K_f = 3mv_o^2$

Collision 1

$$v_{f,3m} = \frac{2(6m)}{3m + 6m}v_0 = \frac{4}{3}v_0$$

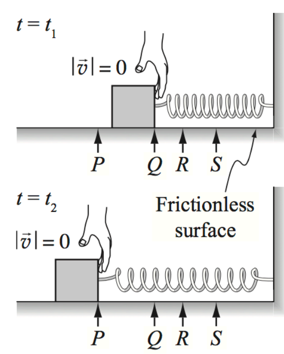
Collision 2

$$v_{f,m} = \frac{2(3m)}{3m + m}\frac{4}{3}v_0 = \frac{6}{4}\frac{4}{3}v_0 = 2v_0$$

Final kinetic energy

$$K_{f,m} = \frac{1}{2}m(2v_0)^2 = 2mv_o^2$$

31. [6 pts] A block on a table is connected to a spring, as shown at right. At time t_1, the block is at point *Q*, and the spring is at its equilibrium length. The block is pushed to the left, stretching the spring. At time t_2, the block is at point *P*. The block begins and ends at rest. Over the interval from t_1 to t_2, is the absolute value of the work on the block by the hand *greater than, less than,* or *equal to* the absolute value of the work on the block by the spring?



A) Greater than

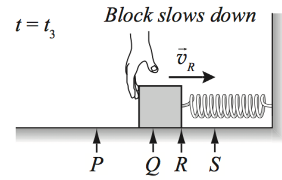
B) Less than

C) Equal to

D) Not enough information to answer.

The block starts at ends at rest. Therefore the change in kinetic energy of the block is zero and the net external work on the block is zero. The hand does positive work on the block since the hand force is to the left and the displacement of the block is to the left. The spring does negative work on the block since the hand force is to the left and the displacement of the block is to the left. For the net external work to be zero, the magnitude of these works must be the same.

32. [6 pts] The block is now released, and it moves back toward point *Q*. When it passes point *Q,* a hand begins to push the block *to the right,* compressing the spring. The hand pushes the block, which passes point *R* with speed v_R at time t_3, until it reaches point *S* at time t_4. The block *slows down* as it moves from point *R* to point *S*. Over the interval from t_3 to t_4 *(i.e.,* as the block moves from *R* to *S),* does the total energy of the block-spring system *increase, decrease,* or *stay the same?*



A) Increase

B) Decrease

C) Stay the same

D) Not enough information to answer.

During the interval from t3 to t4, there are four external forces on the block spring system (1) the force by the hand, (2) the normal force by the floor, (3) the gravitational force by the Earth and (4) the force by the wall. Forces, 2-4 don't do any work on the block-spring system, but the hand force does positive work on the system. This positive work must lead to an increase in the total energy of the system.