UP 1 Exam 1 Fall 2022

Your Full Name: ______________________________
Class time: _____________

Academic Integrity agreement:

You acknowledge that you will not give or receive any help on this exam, and **all work will be one hundred percent your own.**

You acknowledge that there will be strict consequences for academic dishonesty.

Your Signature: ________________________

Leave this exam packet closed until instructed to begin.

You CAN and SHOULD write on this exam.
Write your answer choices in the boxes provided.

1. (3 pts) The formula for the acceleration of an object traveling through water is given in m/s² by: $a(t) = Dv^2$, where *D* is a positive constant and *v* is velocity in m/s. What are the SI units of *D*?
   A. $\dfrac{kg}{m^3}$
   B. $\dfrac{kg}{s^2}$
   C. $\dfrac{m}{s^2}$
   D. $\dfrac{1}{m}$
   E. $\dfrac{s}{m}$

1.____

D: 3

2. (3 pts) A student performs an experiment to measure the measure the magnitude of the acceleration due to gravity, and they obtain the results:

   (9.4051 ±0.3726) m/s².

   They write the result in several ways. Which of the following is correct and expressed in proper form as required for UPI lab reports?

   A. 9.405 m/s² ± 0.373
   B. (9.4 ± 0.4) m/s²
   C. (9.40 ± 0.3726) m/s²
   D. (9 ± 0.4) m/s²
   E. (9.41 ± 0.373) m/s²

2.____

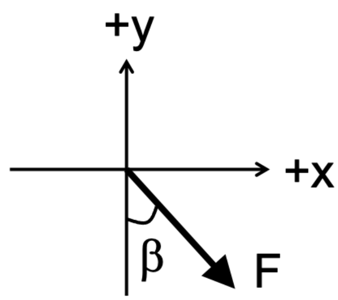
B: 3

3. (3 pts) A ball is tossed at an upward angle off a tall building. As it travels through the air, it follows a parabolic trajectory. Ignore air resistance. Which statement is TRUE for the motion in the air?
   A. The velocity is perpendicular to the acceleration for one instant only.
   B. The velocity is always perpendicular to the acceleration.
   C. The velocity is always parallel to the acceleration.
   D. The velocity is perpendicular to the acceleration for two instants.
   E. The velocity is never perpendicular to the acceleration.

3.____

A: 3

4. (3 pts) A vector of length F makes an angle of β with the negative y-axis as shown. Write this in unit vector notation.



A. $-F\,\hat{\imath} - F\,\hat{\jmath}$

B. $(-F\sin\beta)\,\hat{\imath} - (F\cos\beta)\,\hat{\jmath}$

C. $(-F\cos\beta)\,\hat{\imath} + (F\sin\beta)\,\hat{\jmath}$

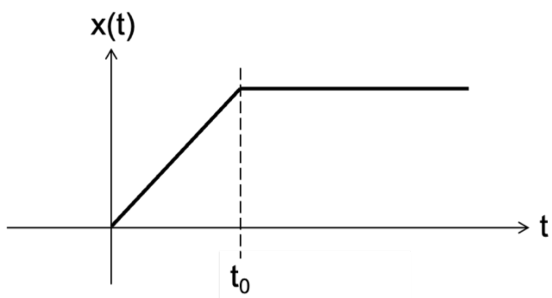
D. $(F\cos\beta)\,\hat{\imath} - (F\sin\beta)\,\hat{\jmath}$

E. $(F\sin\beta)\,\hat{\imath} - (F\cos\beta)\,\hat{\jmath}$

4._____

D: 1
E: 3

5. (3 pts) Consider the position versus time graph shown for a particle moving in one dimension. Which statement best describes the motion during the time shown?



5._____

E: 3

A. The particle is continuously going in the positive x direction.
B. The acceleration is non-zero from 0 to t_0.
C. The particle is at rest the entire time shown.
D. The velocity increases up to a time t_0, and then the velocity becomes constant.
E. The particle moves at a constant velocity up to a time t_0, and then it stops.

6. (3 pts) A rocket moves in one dimension. Its position as a function of time is given in meters by:

$$x(t) = 2 - 3t^2 + 4t^3.$$

At which time(s) is the rocket instantaneously at rest?

A. t = 0.5 s only
B. t = 0 s only
C. t = 0 and 0.5 s only
D. The rocket is never at rest for any value of $t \geq 0$.
E. t = 0 and 2 s only

6._____

A: 1
B: 1
C: 3
E: 1.5

7. (3 pts) A car starts from rest and accelerates with a constant acceleration in one dimension. It travels a distance D in a time t_1. What is the magnitude of the acceleration of the car?

A. Dt_1^2

B. $\frac{D}{t_1^2}$

C. $\frac{D}{2\,t_1^2}$

D. $\frac{D^2}{t_1}$

E. $\frac{2D}{t_1^2}$

7.____

C: 1.5
E: 3

8. (3 pts) A block of mass m slides down the ramp pictured below. The ramp has a coefficient of kinetic friction μ_k. What is the magnitude of the friction force on the block?

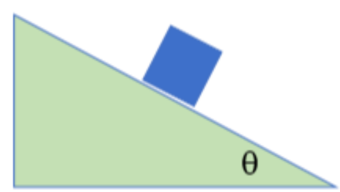
A. $mg(\sin\theta)$

B. $\mu_k mg(\cos\theta)$

C. 0

D. $\mu_k mg$

E. $\mu_k mg(\sin\theta)$

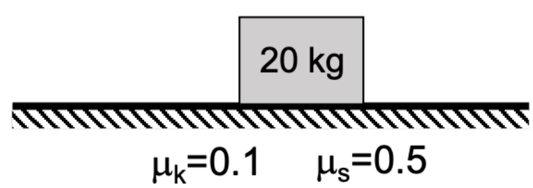


8.____

B: 3
E: 1.5

9. (3 pts) A box of mass 20.0 kg is initially at rest on a level table. The coefficient of kinetic friction between the box and the table is 0.100, and the coefficient of static friction is 0.500.

You apply a horizontal force of 50.0 N to the box. Besides friction, this is the only horizontal force acting on the block. What is the magnitude and type of friction force acting on the block while you apply this force?

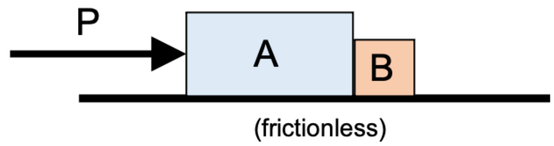


A. 98.0 N kinetic friction
B. 19.6 N static friction
C. 50.0 N static friction
D. 98.0 N static friction
E. 19.6 N kinetic friction

9.____

C: 3
D: 1
E: 1

10. (3 pts) Two blocks are accelerating towards the right across a frictionless table as a result of a horizontal force of magnitude *P* as shown. Block A is more massive than block B.



Let $F_{A\ on\ B}$ denote the magnitude of the force that block A exerts on block B.
Let $F_{B\ on\ A}$ denote the magnitude of the force that block B exerts on block A.

Which ranking statement is true?

A. $P > F_{A\ on\ B} = F_{B\ on\ A}$

B. $F_{A\ on\ B} = F_{B\ on\ A} > P$

C. $F_{A\ on\ B} = F_{B\ on\ A} = P$

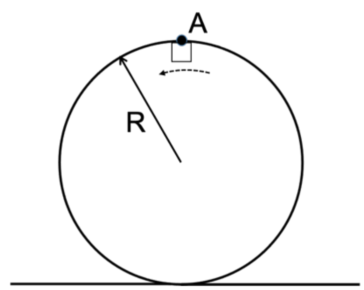
D. $P > F_{A\ on\ B} > F_{B\ on\ A}$

E. $P > F_{B\ on\ A} > F_{A\ on\ B}$

10.____

A: 3

11. (3 pts) A block is traveling around a loop-the-loop as shown. When it is upside down at the top of the circle (at point A), which one of the following statements about the block is **true**?



A. The normal force is downwards, but the acceleration and net force are upwards.

B. The weight of the block is equal to the normal force on the block.

C. There are no upward forces acting on the block.

D. The acceleration is downwards, but the net force is upwards, away from the center of the circle.

E. The acceleration and net force are downwards, but the normal force on the block is upwards.

11.____

C: 3

12. (3 pts) A particle has a displacement given by:

$$\Delta\vec{r} = (2.0\text{ m})\,\hat{\imath} - (5.0\text{ m})\,\hat{\jmath}$$

while being acted upon by a constant force:

$$\vec{F} = (3.0\text{ N})\,\hat{\imath} - (4.0\text{ N})\,\hat{\jmath}.$$

What is the **work done** on the particle by this force during this displacement?

A. It depends on the mass of the particle.

B. $(6.0\text{ J})\hat{\imath} + (20.0\text{ J})\,\hat{\jmath}$

C. $+26.0\text{ J}$

D. $+3.0\text{ J}$

E. $+14.0\text{ J}$

12.____

C: 3

13. (3 pts) A person pulls a box along a horizontal surface by applying a constant force **F** at an angle θ above the horizontal. As a result, the box travels a horizontal distance *d*. What is the work done on the box by the person during this motion?

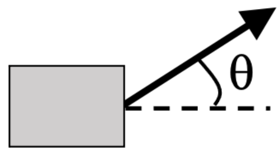
A. $Fd\sin\theta$

B. $\dfrac{Fd}{\cos\theta}$

C. $\dfrac{Fd}{\sin\theta}$

D. $Fd\cos\theta$

E. Fd

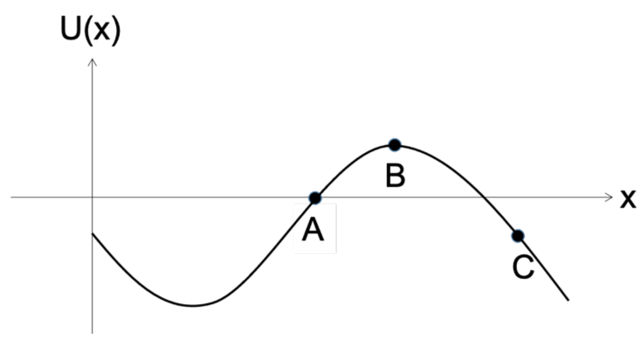


13.____

D: 3

14. (3 pts) A conservative force acts on a particle. The potential energy diagram, U(x), corresponding to this force is shown. At which of the labeled point(s) would this force acting on the particle be zero?

A. At point A only
B. At point B only
C. At point C only
D. At both A and B
E. Not enough information to answer



14.____

B: 3

15. (3 pts) A potential energy varies with position and is given in Joules by

$$U(x) = +Dx^4\,,$$

where D is a positive constant. What is the force associated with this potential energy?

A. $F_x = +4Dx^3$

B. $F_x = -4Dx^3$

C. $F_x = -\dfrac{Dx^5}{5}$

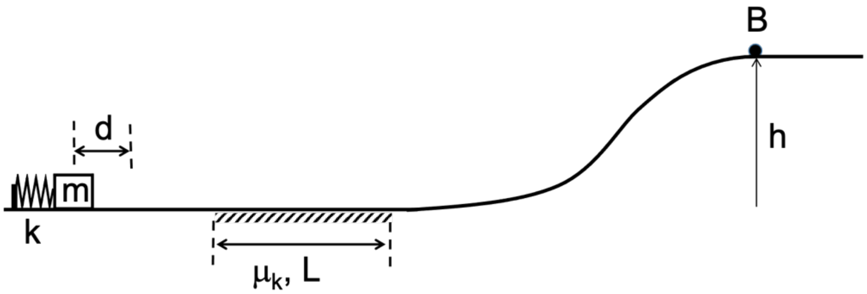
D. $F_x = +\dfrac{Dx^5}{5} - mg$

E. $F_x = +\dfrac{Dx^5}{5}$

15.____

A: 1.5
B: 3

16. A block of mass *m* is initially compressing a spring (with spring constant *k*) by a distance *d*. It is released from rest, causing it to slide across a level friction path of length *L* and coefficient of kinetic friction μ_k. After the friction patch, it rises up a hill of height *h*.



You want to find the speed, *v*, of the mass when it is at the top of the hill (at point B). Which is the correct equation for this problem?

A. $\frac{1}{2}kd^2 + \frac{1}{2}mv^2 + mgh = \mu_k mgL$

B. $\frac{1}{2}kd^2 = \frac{1}{2}mv^2 + mgh + \mu_k mg$

C. $\frac{1}{2}kd^2 = \frac{1}{2}mv^2 + mgh - \mu_k mgL$

D. $\frac{1}{2}kd^2 = \frac{1}{2}mv^2 + mgh + \mu_k mgL$

E. $kd = \frac{1}{2}mv^2 + mgh + \mu_k mg$

16.____

B: 1
C: 1
D: 3

Problems 17 – 26 involve more work and are worth 5 points each.

17. Consider the two force vectors:

$$\vec{F}_1 = (3\,\hat{\imath} - 8\,\hat{\jmath})\text{ N}$$
$$\vec{F}_2 = (-5\,\hat{\imath} + 20\,\hat{\jmath})\text{ N}$$

What is the direction of the total force vector, $\vec{F}_{tot} = \vec{F}_1 + \vec{F}_2$, measured in degrees counterclockwise from the +*x* axis?

A. $\theta = +170.5°$

B. $\theta = +99.5°$

C. $\theta = +80.5°$

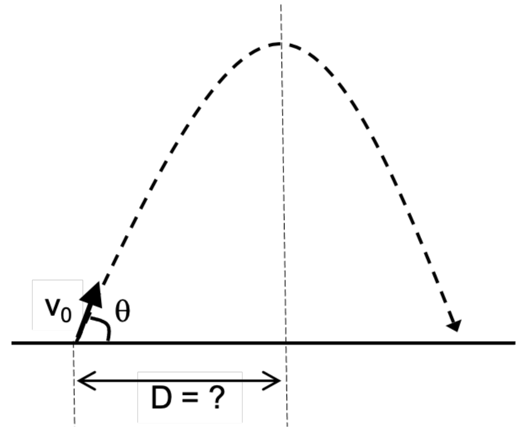
D. $\theta = +260.5°$

E. $\theta = +104.5°$

17.____

A: 1.5
B: 5
C: 1.5

18. A cannonball is fired from the ground with an initial speed of v_0 = 30.0 m/s at an angle of 30.0° as shown. What is the horizontal displacement, D, of the cannonball when it has reached its highest point? Take g = 9.8 m/s^2.

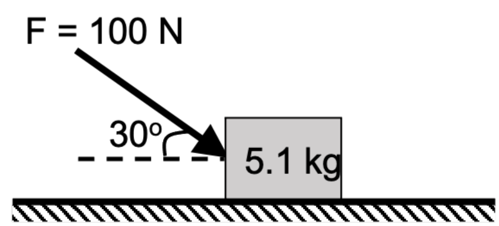


A. 79.5 m
B. 28.3 m
C. 39.8 m
D. 45.9 m
E. 91.8 m

18._____

C: 5

19. A 5.1 kg crate sits at rest on a level floor. It is found that when a force F = 100 N is applied at a downward angle of 30° as shown, then the crate will just begin to move. What is the coefficient of static friction?



A. 0.87
B. 1.73
C. 0.50
D. 1.15
E. 0.58

19._____

A: 5
B: 2.5
D: 2.5

20. Say that the **time-varying** velocity of an object moving **in two dimensions** is given in m/s by:

$$\vec{v}(t) = (At^2)\,\hat{\imath} - (Bt^3)\,\hat{\jmath}.$$

where A and B are positive constants. The object started at position (x_0, y_0) at t = 0. What is the correct equation for the **position** as a function of time?

A. $\vec{r}(t) = \left(\frac{At^3}{3} - x_0 t\right)\hat{\imath} + \left(-\frac{Bt^4}{4} + y_0 t\right)\hat{\jmath}$

B. $\vec{r}(t) = \left(\frac{At^3}{3} + x_0\right)\hat{\imath} + \left(-\frac{Bt^4}{4} + y_0\right)\hat{\jmath}$

C. $\vec{r}(t) = (2At)\,\hat{\imath} - (3Bt)\,\hat{\jmath}$

D. $\vec{r}(t) = (2At + x_0)\,\hat{\imath} - (3Bt + y_0)\,\hat{\jmath}$

E. $\vec{r}(t) = \left(\frac{At^3}{3} - \frac{Bt^4}{4} + x_0 + y_0\right)$

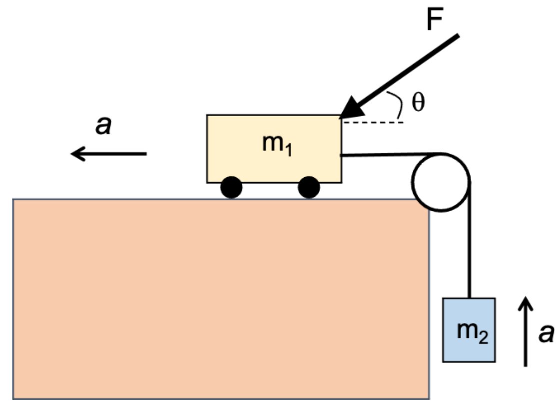
20.____

A: 2.5
B: 5

21. A frictionless cart of mass m_1 and a block of mass m_2 are connected by a massless rope, as shown. The rope passes over an ideal massless pulley, as shown. Your lab partner pushes on the cart, causing both masses to accelerate as shown. There is no friction or air resistance.

The magnitude of the applied force is F and it makes an angle θ with the horizontal. The magnitude of the acceleration is a and the magnitude of the tension in the rope is T.

What is the correct Newton's 2nd Law equation of motion for each object?



A. $F\cos\theta + T = +m_1 a$
$T - m_2 g = -m_2 a$

B. $F\cos\theta + T = +m_1 a$
$T - m_2 g = +m_2 a$

C. $F\cos\theta - T = +m_1 a$
$T - m_2 g = +m_2 a$

D. $F\sin\theta + T = +m_1 a$
$T - m_2 g = +m_2 a$

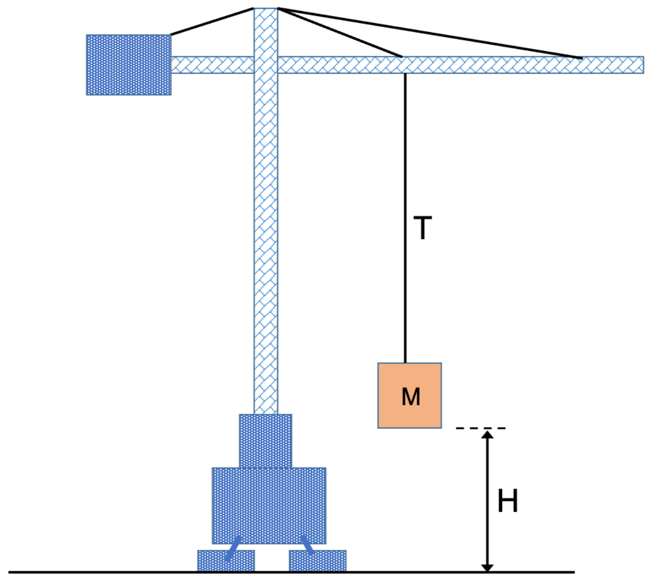
E. $F\cos\theta - T = -m_1 a$
$T - m_2 g = -m_2 a$

21.____

B: 2.5
C: 5
D: 2.5

22. A heavy box of mass *M* is being lowered by a crane. It starts **from rest** at a height *H*. As it is being lowered, it accelerates downwards at a constant rate. While it is accelerating downwards, the magnitude of the tension *T* in the crane's cable is $T = \frac{7mg}{8}$.

How much **time** does it take the box to travel the vertical distance H?



A. $\sqrt{\frac{16H}{g}}$

B. $\sqrt{\frac{7H}{g}}$

C. $\sqrt{\frac{16H}{7g}}$

D. $\sqrt{\frac{7H}{8g}}$

E. $\sqrt{\frac{10H}{g}}$

22.____

A: 5
C: 1.5

23. A block is initially at the origin (0, 0) and at rest. A **two dimensional** conservative net force that **varies with position** is then applied to the block. The net force is given in Newtons by:

$$\vec{F} = 2x\,\hat{\imath} + 4y\,\hat{\jmath}$$

where *x* and *y* are the positions in meters.
What is the **total change in kinetic energy** of the block after it has moved along *x* from *x* = 0 to *x* = 3 m, and then along *y* from *y* = 0 to *y* = 3 m?

A. 45 J
B. Impossible to determine without the mass
C. 27 J
D. 18 J
E. 9 J

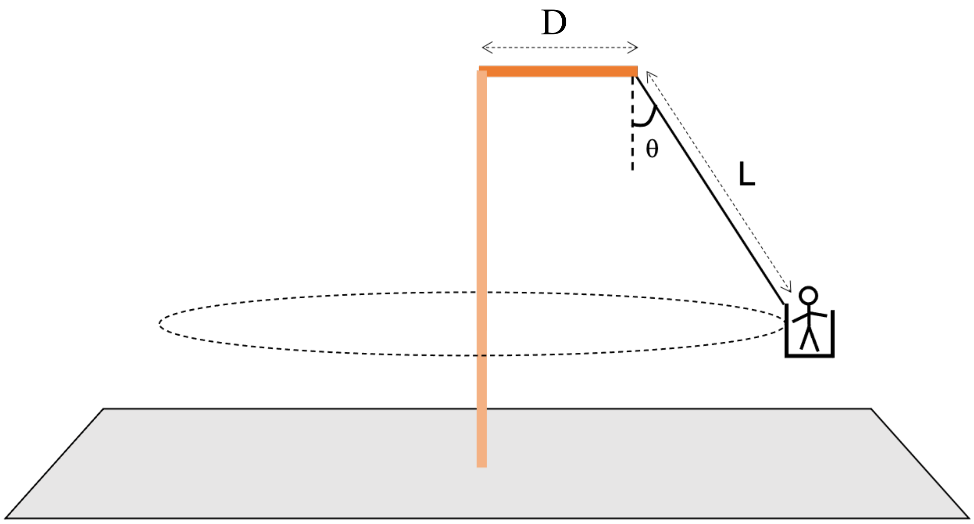
23.____

A: 2.5
C: 5

24. Consider a person on a ride at a state fair. The ride's chair is attached to a cable that has a magnitude of tension *T* and has a length *L*. The cable is attached to a rigid horizontal beam of length *D*.

The ride is rotated at a constant rate, causing the person to move in the horizontal circular path shown at a **constant speed**.

When the person's speed is *v*, the cable makes an angle θ with the vertical as shown. Take the total mass of the person and chair to be *m*.



Which of the following is the correct Newton's 2nd Law equation of motion for the horizontal direction?

A. $T\sin\theta + \frac{mv^2}{D+L\sin\theta} = 0$

B. $T\sin\theta + F_{centripetal} = \frac{mv^2}{D+L\sin\theta}$

C. $T\sin\theta = \frac{mv^2}{D+L\sin\theta}$

D. $T\cos\theta = \frac{mv^2}{D+L\sin\theta}$

E. $T\sin\theta + \frac{mv^2}{D} = 0$

24._____

A: 1.5
C: 5
D: 2.5

25. A block of mass *m* has an initial speed v_0 . It then heads into a level rough patch. The coefficient of kinetic friction in the rough patch is μ_k. What is the maximum distance, *L*, that it goes before stopping?

A. $\frac{{v_0}^2}{4\mu_k g}$

B. $\frac{{v_0}^2}{\mu_k g}$

C. $\frac{{v_0}^2}{2g}$

D. $\frac{{v_0}^2}{g}$

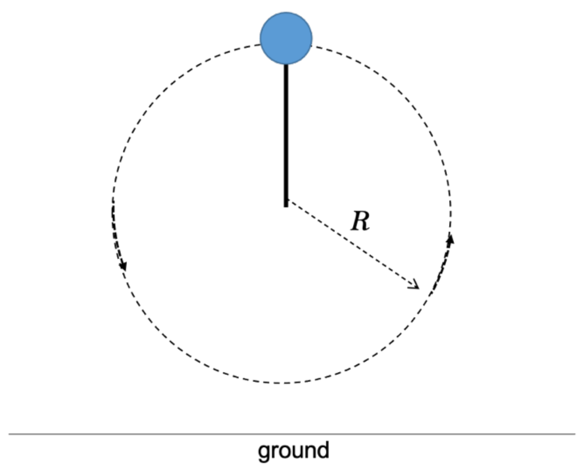
E. $\frac{{v_0}^2}{2\mu_k g}$

25.____

E: 5

26. A ball (of weight *mg*) is swung very quickly in a vertical circle as shown. The radius of the circle is *R*. The tension in the rope when the ball is at the **top** of the circle is equal to 21*mg*.

What is the speed of the ball at the **bottom of the loop**? Ignore friction and air resistance.



A. $\sqrt{23gR}$

B. $\sqrt{25gR}$

C. $\sqrt{22gR}$

D. $\sqrt{24gR}$

E. $\sqrt{26gR}$

26.____

D: 2.5
E: 5