UNIVERSITY OF MANITOBA

October 29, 2015 — MID-TERM TEST
(7:00 pm – 9:00 pm) — (+ Formula Sheet)

PAPER NO.: **A**

DEPARTMENT & COURSE NO.: PHYS 1020 — TIME: 2 hours

EXAMINATION: General Physics 1 — EXAMINERS: W. Ens, K. Shamseddine, P. Zetner

All questions are of equal value. No marks are subtracted for wrong answers.

Record all answers on the computer score sheet provided. **USE PENCIL ONLY!** Black pen will look good but may not be read reliably by the scoring machine. **Mark only one answer for each question!** Select the answer which is closest to yours.

A formula sheet is provided for your use; you may **not** use your own formula sheet. Calculators should have limited memory capacity and should not be capable of remote communication. No phones or handheld computers (PDAs) or notes are permitted.

Unless the question specifically asks about significant figures, an answer should NOT be considered to be incorrect if the number of significant figures does not match the significant figures supplied in the question.

Be sure your name and 7-digit student number are printed on the score sheet and your student number is correctly coded in the box at the top right-hand side of the sheet.

This is paper **A**. Questions are numbered 1 to 20. Mark the correct answers in rows 1-20 of the accompanying IBM sheet in pencil. Also write "**Paper A**" next to your name on the IBM sheet.

TABLE OF CONSTANTS

$G = 6.673\times10^{-11}\ m^3kg^{-1}s^{-2}$ — Mass of the earth = 5.98×10^{24} kg

$g = 9.8\ m/s^2$ — 1 tonne = 10^3 kg

Radius of the earth = 6.38×10^3 km

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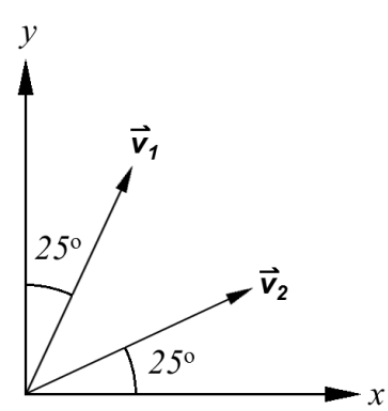
1. The figure shows two velocity vectors, $\mathbf{v_1}$ and $\mathbf{v_2}$, drawn in the xy plane. Both vectors have the same magnitude, v. The x and y components of the difference vector $\Delta\mathbf{v} = \mathbf{v_2} - \mathbf{v_1}$ are:



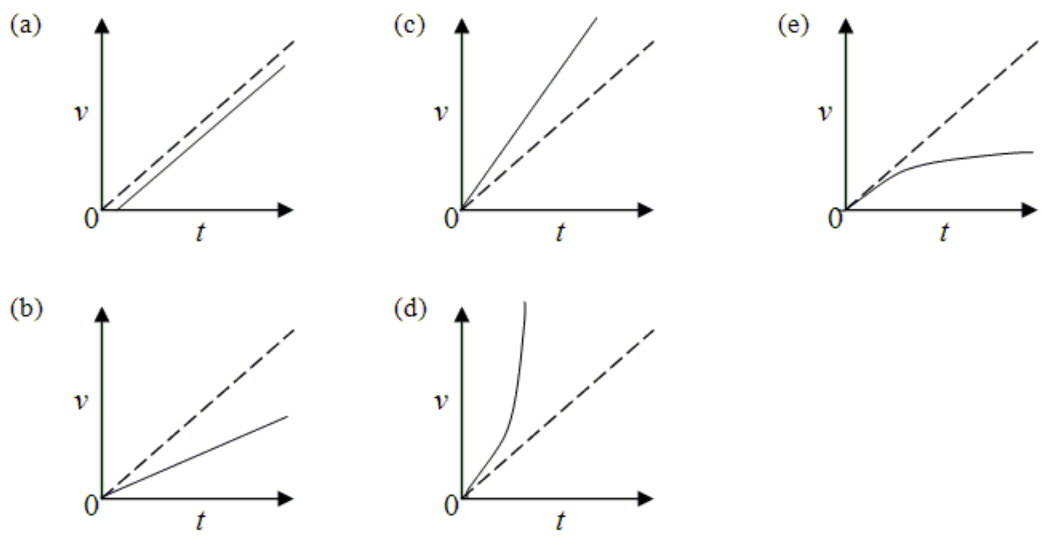
A) $\Delta v_x = 0.906v$; $\Delta v_y = 0.423v$
B) $\Delta v_x = -0.423v$; $\Delta v_y = 0.906v$
C) $\Delta v_x = 0.484v$; $\Delta v_y = -0.484v$
D) $\Delta v_x = -0.484v$; $\Delta v_y = 0.484v$
E) $\Delta v_x = 0.906v$; $\Delta v_y = -0.423v$

2. A car is traveling at constant speed on a circular track of radius r. The period of the motion is t. When the car has traveled halfway around the track, what is the magnitude of its *displacement* from the starting point and its average speed along the route?

A) r, r/t
B) $2r$, $2\pi r/t$
C) πr, $\pi r/2t$
D) $2\pi r$, $4\pi r/t$
E) zero meters, 2r/t

3. If an object is allowed to fall near the earth's surface, and air resistnace is considered, the magnitude of its acceleration would begin at the free-fall value, but it would decrease continuously to zero as the object continued to fall. For which one of the choices given does the solid line best represent the speed of the object as a function of time when it is dropped from rest in air?

   Note: The dashed line shows the speed of an object in free-fall under vacuum for comparison.



A) a B) b C) c D) d E) e

4. A ball is thrown straight up from the surface of the earth with an initial speed of 19.6 m/s. Neglecting any effects due to air resistance, how much time elapses between the throwing of the ball and its return to the original launch point?

   A) 4.00 s B) 2.00 s C) 12.0 s D) 8.00 s E) 16.0 s

5. An object moving along a straight line is decelerating. Which one of the following statements concerning the object's acceleration is *necessarily* true?

   A) The value of the acceleration is positive.
   B) The direction of the acceleration is in the same direction as the displacement.
   C) An object that is decelerating has a negative acceleration.
   D) The direction of the acceleration is in the direction opposite to that of the velocity.
   E) The acceleration changes as the object moves along the line.

6. A car starts from rest and accelerates at a constant rate in a straight line. In the *first* second the car moves a distance of 2.0 meters. How fast will the car be moving at the end of the *second* second?

   A) 4.0 m/s B) 16 m/s C) 2.0 m/s D) 32 m/s E) 8.0 m/s

7. A ball is fired at an angle of 45º to the horizontal, the angle that yields the maximum range in the absence of air resistance. What is the ratio of the ball's maximum height to its range?

A) 1.0 B) 0.75 C) 0.67 D) 0.50 E) 0.25

8. Airplane One flies due east at 250 km/h relative to the ground. At the same time, Airplane Two flies 330 km/h, 35º north of east relative to the ground. What is the velocity of Airplane One relative to Airplane Two?

A) 16 km/h, due west
B) 270 km/h, due north
C) 210 km/h, 55º south of east
D) 170 km/h, 15º north of east
E) 190 km/h, 84º south of west

9. At time $t = 0$ s, a puck is sliding on a horizontal table with a velocity 3.60 m/s, 35.0º above the $+x$ axis. As the puck slides, a constant acceleration acts on it that has the following components: $a_x = -0.360$ m/s^2 and $a_y = -0.980$ m/s^2. What is the velocity of the puck at time $t = 1.50$ s?

A) 1.83 m/s, 12.0º above the $+x$ axis
B) 2.04 m/s, 21.2º above the $+x$ axis
C) 1.06 m/s, 11.7º above the $+x$ axis
D) 2.48 m/s, 13.9º above the $+x$ axis
E) 1.38 m/s, 15.2º above the $+x$ axis

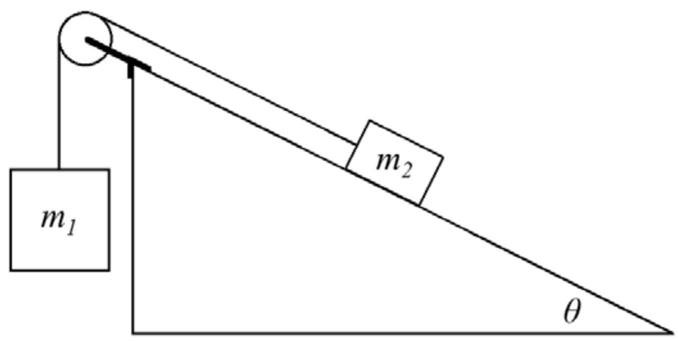
10. A locomotive pulls ten identical freight cars with an acceleration of 2.0 m/s^2. The force between the locomotive and the first car is $1.0\text{x}10^5$ N. What is the force exerted by the ninth car on the tenth car? (There is no friction to consider.)

A) $1.0\text{x}10^5$ N B) $9.0\text{x}10^4$ N C) $5.0\text{x}10^4$ N D) $1.0\text{x}10^4$ N E) $0.5\text{x}10^4$ N

11. A 30.0 kg golden retriever stands on a scale in an elevator. The elevator is moving with an acceleration of 3.50 m/s^2 downwards. The scale reading is:

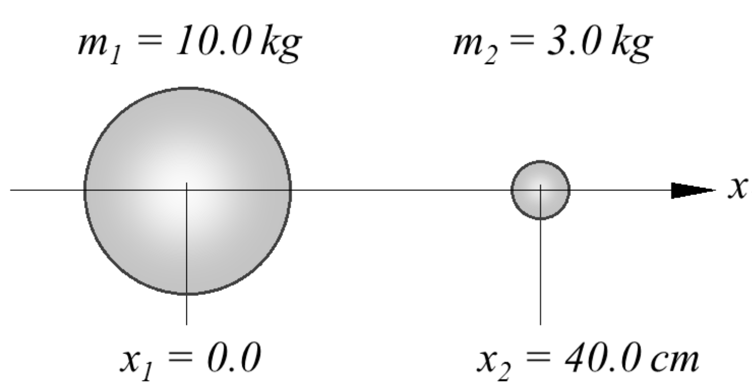
A) 0 N (weightlessness) B) 105 N C) 294 N D) 399 N E) 189 N

12. Two blocks are connected over a massless, frictionless pulley. Block m_1 has a mass of 2.00 kg and is accelerating downwards. Block m_2 has a mass of 1.00 kg and is in contact with the inclined plane surface. The angle ,θ, of the incline is 30 degrees. The coefficient of kinetic friction between block m_2 and the incline is $\mu_k = 0.400$. What is the magnitude of the acceleration of block m_1?



A) 11.3 m/s^2 B) 5.65 m/s^2 C) 9.80 m/s^2 D) 3.77 m/s^2 E) 4.90 m/s^2

13. Two masses, m_1 and m_2 , are fixed in position along the x axis, as shown in the figure. Find the x coordinate of a third mass, $m = 1.00$ kg, located on the x axis, such that the net gravitational force on it due to m_1 and m_2 is exactly zero.



A) 9.6 cm B) 30.4 cm C) 25.8 cm D) 3.6 cm E) 20.0 cm

14. An indoor track is to be designed such that each end is a banked semi-circle with a radius of 24 m. What is the optimal banking angle for a person running at speed $v = 6.0$ m/s?

A) 8.7° B) 11° C) 14° D) 22° E) 45°

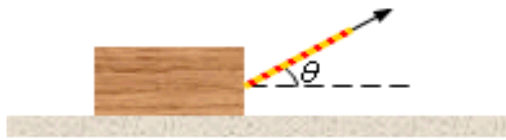
15. Callisto and Io are two of Jupiter's moons (satellites). The distance from Callisto to the center of Jupiter is approximately 4.5 times farther than the distance from Io to the center of Jupiter. How does Callisto's orbital period, T_C, compare to that of Io, T_I?

A) $T_C = 4.5\ T_I$ B) $T_C = 21\ T_I$ C) $T_C = 9.5\ T_I$ D) $T_C = 0.2\ T_I$ E) $T_C = 2.7\ T_I$

16. A 0.75-kg ball is attached to a 1.0-m rope and whirled in a vertical circle. The rope will break when the tension exceeds 450 N. What is the maximum speed the ball can have at the bottom of the circle without breaking the rope?

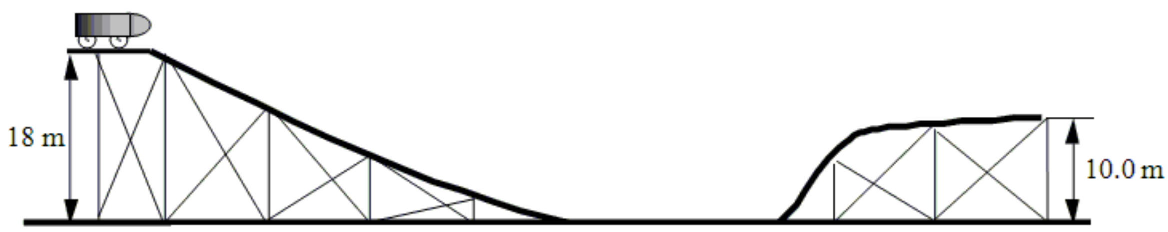
A) 24 m/s B) 12 m/s C) 32 m/s D) 16 m/s E) 38 m/s

17. A concrete block is pulled 7.0 m across a frictionless surface by means of a rope. The tension in the rope is 40 N; and the net work done on the block is 247 J. What angle does the rope make with the horizontal?



A) 28° B) 41° C) 47° D) 62° E) 88°

18. A roller coaster starts from rest at the top of an 18-m hill as shown. The car travels to the bottom of the hill and continues up the next hill that is 10.0 m high.



How fast is the car moving at the top of the 10.0-m hill, if friction is ignored?

A) 6.4 m/s B) 8.1 m/s C) 13 m/s D) 18 m/s E) 27 m/s

19. The initial velocity of a 4.0-kg box is 11 m/s, due west. After the box slides 4.0 m horizontally, its speed is 1.5 m/s. Assuming that friction is the only non-conservative force acting on the box as it slides, determine the magnitude and direction of the force of friction.

A) 42 N, due west
B) 120 N, due east
C) 31 N, due east
D) 59 N, due east
E) 83 N, due west

20. How much power is needed to lift a 75-kg student vertically upward at a constant speed of 0.33 m/s?

A) 12.5 W B) 25 W C) 115 W D) 230 W E) 243 W

Mathematics

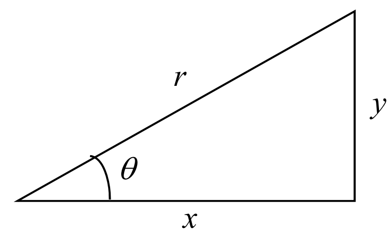
Quadratic equation:

$$ax^2 + bx + c = 0$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Trigonometry:

$$r^2 = x^2 + y^2$$
$$\sin\theta = y/r$$
$$\cos\theta = x/r$$
$$\tan\theta = y/x$$



Kinematics (for constant acceleration)**:**

$$v = v_0 + at$$

$$x = \tfrac{1}{2}(v_0 + v)t$$

$$x = v_0 t + \tfrac{1}{2}at^2$$

$$v^2 = v_0^2 + 2ax$$

Forces:

Newton's second law: $\sum \vec{\mathbf{F}} = m\vec{\mathbf{a}}$

First condition for equilibrium: $\sum \vec{\mathbf{F}} = 0$

Gravity:

Gravitational force near the earth: $F = mg$

Newton's law of universal gravitation: $F = G\dfrac{m_1 m_2}{r^2}$

$g = 9.80 \text{ m/s}^2$ $\qquad G = 6.67\times10^{-11} \text{ N}\cdot\text{m}^2/\text{kg}^2$

Friction:

Static: $0 \le f_s \le \mu_s F_N$ direction is always opposite to motion (or tendency to motion)

Kinetic: $f_k = \mu_k F_N$

Uniform Circular Motion

Period: $T = \dfrac{2\pi r}{v}$, where v is the speed of the object and r is the radius of the circle

Frequency: $f = \dfrac{1}{T}$

θ (in radians) $= \dfrac{\text{Arc length}}{\text{radius}}$

Centripetal Acceleration: $a_c = \dfrac{v^2}{r}$

Centripetal Force: $F_c = \dfrac{mv^2}{r}$ (directed towards the centre)

Work, Energy, and Power:

Work: $W = (F\ \cos\theta)\ s$

Kinetic energy: $\text{KE} = \tfrac{1}{2}mv^2$

Potential energy:

Gravitational (near Earth): $\text{PE} = mgh$

Work-energy theorem: $W_{\text{nc}} = \Delta\text{KE} + \Delta\text{PE} = E_f - E_i$

Total mechanical energy: $E = \text{KE} + \text{PE}$

Conservation of mechanical energy: $E = \text{KE} + \text{PE} = \text{constant};\ E_f = E_i$

Power (rate of doing work): $\overline{P} = \dfrac{W}{t}$

Answers for Paper A

1.	C	11.	E
2.	B	12.	D
3.	E	13.	C
4.	A	14.	A
5.	D	15.	C
6.	E	16.	A
7.	E	17.	A
8.	E	18.	C
9.	D	19.	D
10.	D	20.	E